# THE SCHOBER POWER AMPLIFIERS

## TR-3D AND TR-3M

THE *Schober* ORGAN CORPORATION
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# GENERAL INFORMATION

The Schober TR-3 Power Amplifier is a high-power audio instrument of the highest quality. It is available in two versions, the TR-3D with two channels and the TR-3M with a single channel.

The TR-3D is the equivalent of two separate amplifiers, each with a maximum capability of 70 watts into an 8-ohm speaker system. It can actually be used where two separate amplifiers are required (such as, among other uses, in a Schober Organ), because separation between the channels is 70 db and for all practical purposes interaction between them can be considered to be practically nil. It is also, of course, an ideal power amplifier for stereo music systems, in which it can drive even very inefficient speaker systems with ease.

The TR-3 is highly reliable and is unlikely to stop working for any reason under any reasonable service conditions. If anything does go wrong, however, it is extremely easy to service because its physical construction makes for easy access to all components and connections.

The single-channel TR-3M can be converted at any future time to the dual-channel (or stereo) TR-3D, with the TCK-3 Conversion Kit.

This manual gives you all the information you need about your TR-3 Amplifier. It is divided into several sections.

This *General Information* section describes the finished amplifier, giving detailed specifications and an explanation of the circuitry. The *Assembly* section begins with information about construction procedures and then gives the step by step instructions for assembling the amplifier. In the *Installation And Operation* section you are told about mounting the amplifier, connecting it to your other equipment, and using the controls. And the *Servicing* portion of the manual tells you what to do if anything is wrong; it includes a list of symptoms and probable causes, as well as a voltage table.

The following information on specifications and circuitry are of principal interest to those with technical backgrounds. You need not understand how the amplifier works in order to assemble and use it with complete success.

## SPECIFICATIONS

The following specifications apply to a single TR-3 Amplifier channel—one channel of the TR-3D or the single channel of a TR-3M. Where the existence of a second channel affects a specification, the language makes that fact obvious; where a second channel has no effect, no mention is made.

**Output**: With both channels driven, and with 8-ohm load, rated *RMS continuous output per channel* is 70 watts (with a 117-volt a.c. line).

**Clipping levels**: The maximum available unclipped power under various conditions is as follows.

With 16-ohm load, maximum is 54 watts with one channel driven, 50 watts with both channels driven.

With 8-ohm load, maximum is 87 watts with one channel driven, 78 watts with both channels driven. (When both channels are driven in this way, the circuit breaker *may* open after several minutes.)

With 4-ohm load, maximum is 116 watts with one channel driven, 100 watts with both channels driven. With one-channel operation at this maximum, the thermostat for the driven channel will open after several minutes. With both channels driven at this maximum, the circuit breaker will open after a few seconds.

**IHF Power output**: Maximum available instantaneous unclipped power ("dynamic music power") is 98 watts into 8 ohms, 132 watts into 4 ohms, and 58 watts into 16 ohms. Schober does not believe in using this rating as a comparison between amplifiers, as is so common in advertising; we feel that the RMS continuous power rating is far more valid.

**Frequency response**: 5 Hz to 57 kHz ±¼ db at 1 watt with 8-ohm load.

**Power bandwidth**: 5 Hz to 40 kHz ±½ db at 70 watts with 8-ohm load.

**Harmonic distortion**: Less than 0.1% at any frequency between 20 and 20,000 Hz.

**Intermodulation**: With 8-ohm load and input of 60 and 7,000 Hz mixed 4:1, IM is less than .07% at 70 watts and less than .05% at 1 watt when the sensitivity control is at its minimum. With the sensitivity control at maximum, the figures are .19% at 70 watts and .08% at 1 watt.

**Noise (unweighted)**: 85 db below 70 watts, 8-ohm load.

**Damping factor**: 28 at 1 kHz, infinity at 20 Hz, 19 at 20 kHz.

**Channel separation for TR-3D**: 70 db at 1,000 Hz.

**Input voltage for full output into 8-ohm load**: 1 volt with sensitivity control at minimum, .15 volt with control at maximum.

**Input impedance**: Between 33,000 and 100,000 ohms, depending on volume control setting.

**Protection**: Thermostat and thermistor bias control for each channel protect against overheating. A circuit breaker with an appropriate time-current characteristic protects against overcurrent. The thermostats open when heat sink temperature reaches 200 deg. F and reset automatically when they cool below 185 deg. F. The circuit breaker must be reset with a front-panel pushbutton.

**Stability**: The amplifier is unconditionally stable with any combination of R, C, and L across the output

**Power consumption**: The TR-3D consumes 2.9 amperes at full rated power output with 8-ohm loads, ½ ampere idling. The TR-3M requires 1.7 and ½ amperes, respectively, under the same two conditions.

**Semiconductor complement**: 14 transistors, 8 diodes, 3 thermistors per channel.

**Rectifier**: Fullwave silicon bridge.

**Dimensions**: 5½ inches wide, 8 inches high, 11⅜ deep.

**Mounting**: Any position. Hold-down blocks furnished.

**Weight**: 17½ lbs net, 19 lbs shipping for TR-3D. TR-3M is 16½ lbs net, 18 lbs shipping.

**Conversion Kit**: The TCK-3 Conversion Kit may be added to a TR-3M at any time to convert it to a TR-3D by adding the components required for the second channel and replacing the circuit breaker.

## CIRCUIT DESCRIPTION

The TR-3 Amplifier was designed primarily for use with Schober Electronic Organs, which are sold in kit form. Because these organs are technically and musically sophisticated instruments, many of which are used professionally, the amplifier had to be of corresponding quality, and the design had also to include the utmost reliability, one which would

not stop operating, even to protect itself, except under the most extraordinary conditions.

Reliability assumes even greater importance in organ work than in general music applications. The nature of organ music is such that high signal levels are generated often and for relatively long periods of time. There is no real limit to the time the player may keep his fingers on the keys and, especially in Schober's type of organ design, sustained waveform peaks can build up much more readily than in other kinds of music. This is a good reason why a Schober amplifier must be able to operate for long periods at very high levels without flinching. And it is one reason why we at Schober feel that the only important measure of amplifier output capability is a *continuous* rating, rather than any of the ratings more commonly used, especially in advertising, to rate other amplifiers, such as music power, peak power, and the like. Pure audio quality is also even more important with organ music than otherwise. Distortion of any kind is much more obvious, and the combination of notes that can produce it is likely to be sustained so that the psychological irritant effect of distortion is emphasized.

Apart from these points, Schober amplifier requirements are conventional—flat frequency response and ordinary output and input impedances and connections. The final combination results in an amplifier which is superior for *any* audio application. Schober amplifiers have been used extensively, for example, in broadcast and recording studio monitoring, as well as in home music systems.

## 100% Push-Pull Operation

The TR-3 operates in push-pull from input to output, not simply in the output stage as is conventional. In this respect it is, to our knowledge, unique at this time (early 1974).

In single-ended front end and driver sections odd order harmonic distortion is a problem. With drivers, single-ended operation implies class A, which leads to heating problems. Distortion in single-ended designs is greatest with the driver stage because it usually must drive the relatively low impedance of the output stage, or swing the full power supply voltage, or both.

Consider specifically the driver (though the same argument is applicable to lower-level stages, in smaller degree), when it comes to heating and consequent problems of thermal runaway and destruction. The class A driver must draw essentially the same current when the amplifier is idling as when delivering full power, and a substantial current at that. This means the driver transistor and its collector resistor must run hot. In contrast, the push-pull driver operates class AB and draws high current only when the signal level is high. The idling current—and the idling heat dissipation—is small. So the push-pull driver remains cool.

Distortion: In an amplifier with a unity gain output stage, the driver must be able to swing the full limits of the power supply to drive the output stage to full limits. Degenerative feedback cannot be used as it would reduce driver swing. So the signal in a single-ended driver must be rather highly distorted. Under the load imposed on the driver by the output stage, the saturation side of the waveform is a good replica of the original waveform, but the cutoff side is very much distorted even though operation is below the clipping point. By contrast, each complementary half of the push-pull driver produces little more than half of the waveform. So each half is called on to operate only in the direction of saturation—the way it likes best—and its full capability is directed to this purpose only. The other half operates identically to produce the other half of the waveform. So, with no swing-reducing (and gain-reducing) degeneration, this stage produces a remarkably undistorted waveform right up to the limit of the power supply (after which, of course, there is clipping under the load imposed by the output section).

Attempts to clean up the problems of the single-ended driver with such devices as bootstrapping and active current sources produce nowhere near the improvement achieved with push-pull design—and they create additional problems.

A side benefit of push-pull and its symmetry is its relative immunity to power supply ripple.

## The Details

The circuit consists basically of three distinct "building blocks," each of which—including the output section—is literally a complete push-pull amplifier in its own right, designed for a specific job. The sections are direct-coupled internally as well as to each other. Eliminating coupling capacitors drastically increases reliability over very long time periods and also makes possible instant recovery from overloads. Also, since there is nominally no d.c. voltage at the output because of the balance, the usual large output capacitor is unnecessary.

Each section, except for the last stages of the output but including the driver section, has a good deal of degenerative feedback within it. This is possible for the driver only because the output section has gain, reducing the required driver swing. So each section—voltage amplifier (transistors 11, 12, 18, and 19), driver (transistors 35, 36, 42, and 43), and output (transistors 54, 55, 66, 67, 90, and 91)—individually has a large amount of feedback and relatively low distortion even before any consideration of over-all feedback from output to input.

The output stage is quasi-complementary, but not in the usual configuration. The usual arrangement has been folded inside out, so that transistors 66 and 67, whose bases would normally be near ground potential with a bipolar power supply, now have their bases near the respective supply voltages. This makes it possible to add transistors 54 and 55, with their bases near ground potential; they can be directly coupled to the driver section.

The entire output section is current-limited at every opportunity. This protection consists of resistors 70, 71, 76, 77, 78, and 79—which are really mostly protection for transistors 66 and 67.

## Feedback

The gain of the voltage amplifier and driver sections is about 39 db each. Output section gain is 13 db. Without any feedback, the total open-loop gain would thus be about 91 decibels.

There are two feedback loops (both d.c. as well as a.c.). One is around the output and driver sections only; the other is around the entire amplifier, output to input. The former is about 14 db and the latter 16 to 35, depending on the setting of the sensitivity control. (The sensitivity control is actually a feedback control rather than an ordinary loss type, so all unneeded gain is put to work reducing distortion rather than being thrown away. This also helps reduce the internal impedance.)

There is also an over-all feedback loop for d.c. only, which

reduces the amplifier's d.c. gain to unity. This idea produces exceptional d.c. stability and assures that any direct voltage that might appear at the output is very small.

### Bias And Thermal Stability

There are 11 diode devices in the amplifier, eight of which are for bias control and three—thermistors—for controlling both bias as such and also thermal stability.

Four bias diodes each in the amplifier and driver sections set the biases for those stages. They are mounted on the printed circuit board and are unaffected by heat.

The thermistors are mounted in special clips on the heat sink halfway between the two output transistors. As heat is produced by the output transistors, it is transferred to the sink and picked up by the thermistors. As they, in turn, become warmer, their forward voltage drop decreases, biasing the transistors down, reducing their current, and thus counteracting the tendency of the transistors to conduct more heavily with increased heat—the condition which could otherwise lead to runaway.

If, despite this control, the amplifier should overheat, the thermostat mounted on the other face of the heat sink will open and cut off the a.c. supply. When the excess heat has dissipated and comes below 185 deg. F, the calibration temperature for the thermostats, the thermostats automatically restore the a.c. As mentioned in other parts of this manual, the thermostats will not cut the amplifier off in any normal service, even at full power for long periods, as long as there is at least minimal ventilation.

### Signal Stability And Overload Recovery

There is no kind of output load which can cause instability; the amplifier will not become unstable with any combination of R, L, and C. Even a capacitive load, which causes trouble for many amplifiers if not most, will not make the amplifier oscillate. The L-C-R network at the output helps this stability. In addition, the input has an R-C filter to reduce the possibility of damage that could be caused by extreme high frequencies at high levels.

One of the important features of the TR-3 is that its recovery from an overload is literally instant, with no overshoot, ringing, oscillation, or other spurious response. This is true even with an overload so large as to square up the output fully.

The reason is that there are no coupling capacitors whatever within the amplifier which must have time to change charge state. (The input blocking capacitor is not "inside" the amplifier and has no effect in this respect.)

Not everyone realizes the importance of quick overload recovery, though in the best test reports in the magazines the point is often covered, along with oscilloscope photos showing the results of tone bursts. The significance is twofold. First, when the amplifier is being used at high power, brief signals which actually pass the clipping level go unnoticed because they produce no side effects. Second, and more important, instant overload recovery is what makes the difference in long-period listening satisfaction between two amplifiers with similar static characteristics. Even at relatively moderate listening levels, occasional very high-power peaks occur with most kinds of program material. When the usual amplifier "boings" as a result, the brief instability is not recognizable as such; but there is an impression of a subtle kind of "mishmash effect." With an amplifier such as the TR-3, sound is clear and transparent at *all* levels. The effect is restful, psychologically, with no subconscious hints of alarm from the listener's brain, and—if the rest of the equipment is of comparable quality—enjoyment is complete!

### Packaging

The TR-3's mechanical design is frankly intended to be entirely functional and neat, rather than glittering and jazzy. In most applications, the unit is relegated to some unseen spot to reduce the clutter of visible components, since once it is connected and the controls set there is little need to have immediate access to it. The TR-3 will, of course, fit inside any Schober Organ console. In stereo systems, it is often put in a closet or in some out of the way location within a cabinet. As long as there is some air available to flow over it, that makes good sense.

The most heat is that generated by the output transistors. It is conducted directly to the heat sinks, which are very heavy aluminum plates. A part of the sink heat is conducted to the outer case, which is dark colored aluminum and dissipates efficiently by radiation. The rest is removed by convection, air entering and leaving through the holes in the case and flowing over both surfaces of the heat sinks. Heat produced by the rectifier is conducted to the rear panel, also a dull, dark color on its outer face, from which it is removed by conduction and radiation. The power transformer is cooled by convection.

The entire amplifier is an assemblage of plates rather than a box or chassis as is conventional. All the plates—heat sinks, rear panel, front panel, and transformer chassis—are thermally insulated from each other by nonmetallic shoulder washers at the fastening points. This keeps the heat in each section where it is supposed to be and prevents warmer parts from heating up cooler ones.

This kind of construction also essentially eliminates closed spaces once the cover is removed (an operation of a minute or so), so that all parts and connections are readily available for inspection and service. The copper surface of each printed board is immediately available. Taking out four screws and folding the board over makes its component side available as well, without any connections to be removed.

If you plan to put the amplifier through specification-type tests, please refer to the section headed, "Special Notes For Testers" on page 26. Such tests are, of course, unnecessary for most amplifier users.

# ASSEMBLY

This section is the meat of the instruction manual. It begins with some preliminary information to prepare you for the job of putting the amplifier together. Then the series of step-by-step instructions guides you through the entire sequence of operations at the end of which your TR-3 amplifier will be complete.

Though it is entirely possible to assemble a TR-3 even if you have never done electornic work before, we do not really recommend that this be your first kit project. However, if that is unavoidable, you will be perfectly all right provided you do two things.

A. Request the Schober How-To-Solder Kit. It will be sent to you without charge. It teaches you how to solder, to printed circuit boards and to other terminals and devices, and it gives you practice in various kinds of soldering. When you finish this short "course" in soldering, you may send the results of your practice to us for grading and comment. We will either tell you to go ahead with your project, or tell you what you did wrong. In any event, you will end up a qualified solderer—and nothing is so important for kit success!

B. Simply follow the instructions as written, observing and emulating the drawings, following religiously the warnings and instructions printed below, before the beginning of the actual assembly instruction steps.

## PARTS LIST

The following parts list has two purposes. (1) It permits you to check the parts received against the list so you will be sure you have everything you need. Figs. 1 through 3 will help you recognize parts. (2) It gives you the Schober stock number of each part. If you need to request a new part—because one is missing, defective, or damaged—you should use the Schober part number to avoid confusion.

In actual practice, it is pretty much a waste of time to check the kit for completeness, since packing errors are rare.

**WARNING:** The parts in each envelope marked 1% RESISTORS and MATCHED RESISTORS must remain in that envelope. Parts in any such envelope must not be mixed with parts in any other envelope, even one with the same marking, nor with parts not in such envelopes. If you open the envelopes to examine the contents, replace the contents immediately and reseal the envelope with tape or a staple. Do not open an envelope with those markings again until the instruction steps specifically tell you to do so.

The parts list which follows is divided into three sections. The first part lists items which are contained only in a TR-3-M (single-channel) amplifier kit. The second lists parts which are contained in *all* TR-3 kits, both single and dual channels.

The final portion of the list shows parts which are used specifically in *one* amplifier channel. If yours is a 1-channel amplifier, you will have the parts just as specified. If your kit is for a 2-channel amplifier, however, you will have the same parts, but the quantity shown should be doubled. A TR-3M, for example, has 8 100-ohm, ½-watt resistors, just as shown. A TR-3D, however, has 16 of these resistors.

Some of the fastener hardware is divided into envelopes labeled *No. 4 hardware, No. 6,* etc. You should spill the contents of each such envelope into a separate container, making it easier and surer for you to select the right items when required. However, some fastenings—the items listed in the last portion of the parts list—come with various sizes mixed together. Before doing any work, we strongly suggest you go through these mixed up screws, nuts, and lockwashers, one by one. Compare each with the full-size drawings of Fig. 2-A. Add the No. 4 and No. 6 items to those which came in the separate envelopes, and put the No. 2 items in a separate container.

Most experienced kit builders maintain a collection of containers—aluminum frozen food plates, old china bowls, and anything else big enough to get a hand into. Before beginning work, parts are distributed into the containers—resistors into one, capacitors into another, and so on—so that finding a part when required involves no digging into the original bags and boxes.

Don't worry if when you finish the amplifier some hardware is left over. We are well aware that if you have a floor, a small bit of hardware will sooner or later fall on it and disappear forever into the fourth dimension. So we kindly provide a few extras to save you from despair and your trouser knees from ruin. (We do not normally provide extra parts of other kinds, however, not being *that* philanthropic. If you find any of those left over, you had better scramble to discover why you left something out of the amplifier!)

| QUAN | DESCRIPTION | NUMBER |
|---|---|---|
| | **PARTS FOR TR-3M ONLY** | |
| 1 | Hole plug for ¼-inch hole | 09661 |
| 4 | Hole plugs for 3/8-inch holes | 09662 |
| 1 | Wire nut | 0965 |
| | **PARTS FOR ALL TR-3 AMPLIFIERS** | |
| 1 | Front panel | 15603 |
| 1 | Rear panel | 15604 |
| 1 | Left heat sink plate | 15602L |
| 1 | Right heat sink plate | 15602R |
| 1 | Transformer chassis | 15605 |
| 1 | Outer case | 15606 |
| 1 | Rubber grommet for 3/8-inch hole | 08910 |
| 4 | Plastic feet | 08650 |
| 2 | Wooden amplifier mounting blocks | 252294 |
| 6" | Felt | 251150 |
| 2 | 6,000-mfd, 50-volt electrolytic capacitors | 02610 |
| 2 | Capacitor mounting clamps | 092490 |
| 1 | Bridge rectifier | 041020 |
| 1 | Power transformer | 03523 |
| 1 | Illuminated power switch | 05204 |
| 1 | Circuit breaker & hardware | TR-3M: 1421; TR-3D: 1429 |
| 1 | A.c. line cord | 10205 |
| 1 | Single tie point | 19101 |
| 1 | 2-terminal tie point | 19102 |
| 3 | Internal-tooth solder lugs | 19281 |
| 1 | Large plastic cable clamp | 0962 |
| 14" | No. 22 brown wire | 07501 |
| 32" | No. 22 orange wire | 07503 |
| 23" | No. 22 green wire | 07505 |
| 15" | No. 22 blue wire | 07506 |
| 24" | No. 22 purple wire | 07507 |
| 26" | No. 22 gray wire | 07508 |
| 15" | No. 22 white wire | 07509 |
| 25" | No. 20 red stranded wire | 07402 |
| 28" | No. 20 yellow stranded wire | 07404 |
| 56" | No. 20 black stranded wire | 07400 |
| 14" | No. 16 bare wire | 07316 |
| 35" | No. 16 black stranded wire | 07410 |
| 2 | 4-40 X ¼ pan-head machine screws | 08135 |
| 2 | 6-32 X 3/16 pan-head machine screws | 0816 |
| 9 | 6-32 X ½ *black* pan-head machine screws | 08155 |

| QUAN | DESCRIPTION | NUMBER |
|---|---|---|
| 6 | 6-32 X ½ *metal-colored* pan-head machine screws | 08142 |
| 12 | 6-32 X ½ round-head machine screws | 08133 |
| 1 | 6-32 X ¾ round-head machine screw | 08147 |
| 4 | 10-32 X 3/8 round-head machine screws | 08151 |
| 6 | 10-32 X 5/8 pan-head machine screws | 081752 |
| 12 | 4-40 X ½ hex-head self-tapping screws | 08025 |
| 4 | 6-32 X ½ hex-head self-tapping screws | 08016 |
| 4 | No. 10 X 1¼ round-head wood screws | 087530 |
| 1 | 2-56 hex nut | 0821 |
| 2 | 4-40 hex nuts | 0822 |
| 21 | 6-32 hex nuts | 0823 |
| 10 | 10-32 hex nuts | 0828 |
| 1 | No. 4 internal-tooth lockwasher | 0831 |
| 19 | No. 6 internal-tooth lockwashers | 0832 |
| 10 | No. 10 internal-tooth lockwashers | 0834 |
| 6 | No. 6 X ½ flat washers | 0854 |
| 4 | ¾-inch flat washers | 085013 |
| 24 | No. 6 X 5/16 nonmetallic shoulder washers | 085593 |
| 12 | No. 10 X 3/8 nonmetallic shoulder washers | 085592 |
| 2 | Wire brads | 25105 |
| | **PARTS FOR EACH AMPLIFIER CHANNEL** | |
| 1 | 47-ohm, ½-watt resistor | 011470 |
| 8 | 100-ohm, ½-watt resistors | 011101 |
| 1 | 220-ohm, ½-watt resistor | 011221 |
| 4 | 470-ohm, ½-watt resistors | 011471 |
| 2 | 560-ohm, ½-watt resistors | 011561 |
| 2 | 1200-ohm, ½-watt resistors | 011122 |
| 2 | 1500-ohm, ½-watt resistors | 011152 |
| 1 | 2700-ohm, ½-watt resistor | 011272 |
| 2 | 4700-ohm, ½-watt resistors | 011472 |
| 1 | 1-megohm, ½-watt resistor | 011105 |
| 2 | 22-ohm, 1-watt resistors | 013220 |
| 1 | 10-ohm, 2-watt resistor | 015100 |
| 1 | 0.1-ohm, 3-watt resistor | 018001EF |
| 3 | 0.2-ohm, 5-watt resistors | 018002CF |
| 1 | MATCHED RESISTORS envelope containing: | |
| | 2 270-ohm, 2-watt resistors | 015271M |
| | 2 560-ohm, ½-watt resistors | 011561M |
| | 2 680-ohm, 1-watt resistors | 013681M |
| | 4 1,000-ohm, ½-watt resistors | 011102M |
| | 2 1500-ohm, ½-watt resistors | 011152M |
| | 2 22,000-ohm, ½-watt resistors | 011223M |
| | 2 100,000-ohm, ½-watt resistors | 011104M |
| 1 | 1% RESISTORS envelope containing: | |
| | 2 110-ohm, ½-watt resistors | 010111 |
| | 2 240-ohm, ½-watt resistors | 010241 |
| 1 | 47-pf disc capacitor | 020470 |
| 1 | .001-mfd disc capacitor | 020102 |
| 1 | .003-mfd disc capacitor | 020302 |
| 1 | .0022-mfd mylar capacitor | 0281222 |
| 1 | .22-mfd mylar capacitor | 0281224 |
| 2 | 10-mfd, 35-volt nonpolarized electrolytic capacitors | 02510 |
| 2 | 47- or 50-mfd, 25-volt electrolytic capacitors | 0250305 |
| 2 | 100-mfd, 25-volt electrolytic capacitors | 0250314 |
| 1 | 1,000-mfd, 3-volt electrolytic capacitor | 0250313 |
| 1 | 2500-mfd, 3-volt electrolytic capacitor | 0250312 |
| 2 | Special PNP silicon transistor | 045000 |
| 2 | Special NPN silicon transistors | 045500 |
| 3 | 2N2102 NPN silicon transistors | 042102 |
| 3 | 2N4036 PNP silicon transistors | 044036 |
| 1 | 40409 NPN silicon transistor | 0440409 |
| 1 | 40410 PNP silicon transistor | 0440410 |
| 2 | 40411 NPN silicon power transistors | 0440411 |
| 12 | Small transistor sockets | 1803 |
| 2 | Large transistor sockets | 1802 |
| 2 | Insulators for power transistors | 09244 |
| 1 | Capsule of special grease | 25112 |
| 8 | Special silicon diodes | 04D200TR |
| 3 | 1N3754 thermistor diodes | 043754 |
| 3 | Clips for thermistor diodes | 09247 |
| 2 | Small radial-fin heat sinks | 09248 |
| 1 | 10,000-ohm linear potentiometer | 017103LS |
| 1 | 100,000-ohm audio-taper potentiometer | 017104BA |
| 1 | Thermostat, 200 deg. F | 1450 |
| 1 | Printed circuit board | 11507 |

| QUAN | DESCRIPTION | NUMBER |
|---|---|---|
| 1 | Phono jack with nut, washer, and solder lug | 1841 |
| 1 | Phono plug | 10107 |
| 1 | Red binding post | 19507RE |
| 1 | Black binding post | 19507BK |
| 1 | Knob | 1208 |
| 1 | 2-terminal tie point | 19102 |
| 1 | 4-terminal tie point | 19104 |
| 4 | Threaded tubular spacers | 085050 |
| 2 | Small plastic cable clamps | 0963 |
| 2 | Large plastic cable clamps | 0962 |
| 1 | Wooden dowel | 252295 |
| 88" | No. 16 solid white wire | 07119 |
| 13 | Tubular terminals | 08801 |
| 3 | Internal-tooth solder lugs | 19281 |
| 8 | 2-56 X 3/16 round-head machine screws | 08112 |
| 6 | 4-40 X ¼ pan-head machine screws | 08135 |
| 6 | 4-40 X 7/16 round-head machine screws | 08121 |
| 4 | No. 6 X ½ round-head self-tapping screws | 08014 |
| 2 | 3/8-32 hex nuts | 0829 |
| 8 | 4-40 hex nuts | 0822 |
| 4 | No. 2 internal-tooth lockwashers | 0836 |
| 6 | No. 4 internal-tooth lockwashers | 0831 |
| 2 | 3/8 internal-tooth lockwashers | 0839 |
| 2 | 3/8 X 5/8 flat washers | 08558 |

## THE TOOLS YOU NEED

The tools you will need to assemble your TR-3 amplifier are mostly the conventional ones—screwdrivers, nutdrivers, long-nose pliers, diagonal cutting pliers (for cutting wire), slip-joint or gas pliers, and the like.

One special tool we highly recommend is a good wirestripper for removing insulation from the ends of wires. This tool should take off insulation cleanly at one stroke, without nicking the wire and weakening it. There are inexpensive plier-type tools for this purpose, which require you to hold the wire with one hand and pull with the wirestripper in the other. We very much prefer a tool which requires no pulling, such as the General Cement Automatic Speedex wirestripper, Model 744-A or similar. It is available from any good electronic supplier—or you can order one from Schober. It is shown on the last page of the Schober Price Lists.

Please, *do not* strip insulation from wire with a knife, razor blade, or wirecutting pliers. You cannot do it cleanly and —much more important—you will inevitably nick the wire and weaken it. *Any* kind of wirestripper is preferable.

When you use a wirestripper, be sure in every case to use the *largest* notch that will remove the insulation from that size wire. A notch that is too small will nick the wire.

## SOLDERING

NOTICE: READ THE FOLLOWING EVEN IF YOU ARE AN EXPERIENCED ELECTRONICS WORKER.

On the printed circuit board(s) in this kit you *must* use a pencil-type soldering iron with a heating element of not more than 37½ watts and a tip having a chisel shape not larger than ⅛ inch in width. Excessive heat will damage a board. With an iron conforming to these specifications you can hold it in place as long as necessary to be sure the metal and solder are adequately heated. With a hotter iron you risk irreparable damage. That kind of damage—copper foil lifted from the board—voids the guarantee because it can be caused only by ignoring these instructions.

An excellent iron to use, the one which we require assemblers of Schober Organs to use, is made up of Ungar units. This is one of the best soldering irons you can buy. You need the No. 1235 37½-watt heating element, No. 776 handle,

and No. PL333 tip. The combination is very inexpensive and can be obtained from local electronics houses or from Schober.

The same iron does a very good job with all other connections in the amplifier. However, if you wish, you can use a conventional iron or gun for connections which are *not on printed circuit boards.*

You *must* use a 60/40 solder with a *rosin core,* specifically intended for electronic work. Our experience indicates conclusively that no commonly available solder is as good for this kind of work as Ersin Multicore, which is why it is the only kind we make available. Use of any solder not specifically intended for electronic work, as indicated on the package, *automatically voids the guarantee* and may cost you quite a bit of money. Use of any solder other than Ersin Multicore *may* void the guarantee or cause unusual repair charges if in our judgment it is responsible for requiring corrective work. *Cheap solder is expensive!*

Soldering is the most important job in electronic assembly work. The history of the entire kit industry shows conclusively that troubles with finished kits arise almost entirely from poor soldering. Soldering is easy to learn and easy to do. If you are not thoroughly familiar with it, request the no-charge How-To-Solder Kit. Don't take a chance!

## IDENTIFYING PARTS

Drawings to which you will be referred in the instruction steps will help you identify the parts as they are needed, and you need expect no difficulties.

Certain parts, however, must be identified as to *value* as well as category. For example, various capacitors, transistors, and the like may look the same but have a different rating or value. Where that is true, the necessary information is usually printed on the body of the part. To find, for instance, a .01-mfd disc capacitor, you identify the appearance of a disc capacitor from the appropriate illustration, then find one with the number .01 somewhere on it (it may also have other letters and numbers which need not concern you). Or to find an 045000 transistor, you look for one with that number printed on it.

The one kind of part which is not so marked is the cylindrical resistor. These resistors come in three basic sizes, as shown in the top three drawings of Fig. 1—½-watt, 1-watt, and 2-watt. The wattages are determined simply by physical size. Since Fig. 1 is a full-size figure, you can determine resistor wattage just by holding a resistor against the drawings.

A resistor of any wattage may have any of a great quantity of different *resistance values.* Resistance is shown by the color bands encircling a resistor, according to a code in which each digit is represented by a color.

For the purpose of this amplifier it is not worth learning the color code if you do not already know it. Wherever a resistor is required, therefore, its colors will be given.

There is therefore only one point you must remember in choosing a resistor of the right value. It is that the first color mentioned is always that of the band *closest to one end of the resistor.*

Notice in the top drawing of Fig. 1—and on any such resistor in your kit—that band 1 is closer to its end of the resistor than the band marked "ignore" is to its end.

A 470-ohm resistor, for example, has bands yellow-purple-brown. The first color, yellow, is that of the band marked 1 in Fig. 1; the second, purple, is that of the band marked 2; and the third color, brown, is that of the band marked 3.

The fourth band is usually silver or gold. You need pay no attention to it, and it is not mentioned in the instructions.

It is extremely important that you choose resistors with the colors mentioned and in the right order. Look at each resistor closely under a good light to be sure you have the right colors. Some colors do not show up especially well, but close examination will answer any doubts. In any case, because of the particular resistor values used in this kit, there is very little, if any, likelihood that you will confuse them.

If there is any possibility that your color perception is not entirely normal, have a friend go through the resistors and tag each one before you begin. You cannot afford any errors in choosing resistors. (And, incidentally, if your eyesight is not perfect, use a magnifying glass on some of the very small lettering—for example, on some of the transistors.)

Fastenings—screws, nuts, lockwashers—are all identified in the full-size drawings of Fig. 2-A.

When you select a screw, look especially at these things when comparing it with the drawings: the type of head, the length of the threaded part between the underside of the head and the tip, and whether the end is tapered or of the same diameter as the rest of the threaded part.

When you choose a lockwasher, always be sure you have the smallest one that will go over the screw.

The 4-40 and 6-32 nuts are sometimes hard to tell apart by eye. Choose by trial the one that goes on the screw easily but obviously engages its threads and can be tightened.

## SCHOBER PRINTED CIRCUITS

On Schober printed circuit boards the *copper side* is the face having the pattern of lines and circles in metal, which may or may not be copper colored but is obviously metal. The *painted side* is the face on which rectangular, circular, and bullet shaped outlines appear, each identified by numbers or letters outside the outline and connected to it by a short line. Always be absolutely certain you have identified the correct outline; that is why the short line connects each identification to the outline. Do not go simply by the proximity of the number to an outline.

Look at a board—or at Fig. 5, which is a drawing of the painted side. Find the number 35 at about the center. Notice that a short line connects the number to the circle just left of the number. If you did not look at the little line, you might think the 35 referred to the circle above it.

The purpose of placing the numbers outside the outlines is to enable you to locate components after the board has been assembled, if you should need to. If they were within the outlines, they would be covered by the components you had installed.

To install a component on the board, you place the part over the designated outline and pass its wires down through the holes associated with that outline. Where the holes are outside the outline, small lines go from the outline to the holes.

Components which naturally have their wires going in the same direction, such as the flat mylar and disc capacitors of Fig. 3, present no problem. You simply put the wires down through the holes and press the part as close to the board as possible. On the copper side where the wires protrude, you bend them outward slightly so they will hold the part from falling out when you turn the board over.

With parts having wires coming out the ends, such as the

resistors of Fig. 1, the diodes of Fig. 2-B, or the electrolytic capacitors of Fig. 3, bend the wires 90 degrees so they make a sharp right angle with the body of the part and are parallel to each other. Then insert them in the holes, spread them apart a bit on the copper side to hold the part in place, and turn the board over.

**IMPORTANT NOTICE:** Whenever you are told to install a part anywhere in this kit—printed circuit or otherwise—*solder it immediately*, without waiting to be told, unless you are specifically told not to. Then clip off any excess wire. Note again: you will not be instructed to solder and clip off excess wire. *Do it* whenever you install a part or make a connection—unless instructed otherwise.

The distance between printed circuit holes and the separation between the wires of a part are not always the same. Where there is a difference, simply spread the wires apart as necessary and insert them. Bend them whatever way seems obvious to allow you to get the part down to the surface of the printed circuit board.

**NOTE:** All parts go on the *painted* side of the circuit board, in the outlines, as described above, except for a few specific ones. Parts to be placed on the copper side will be especially mentioned in the steps applying to them. Where nothing special is mentioned, place parts on the painted side, with wires or terminals going down through holes and protruding on the copper side, where they are to be soldered.

## FOLLOWING INSTRUCTIONS

The only way you can assemble this amplifier correctly is to follow the instructions. This means doing each operation in the sequence in which it is given, and obeying the instructions in each step *exactly*. Do not use any imagination or try to read between the lines for any hidden meanings or implications. Simply do exactly what you are told—even if you are a professor of electrical engineering.

As you complete each step or portion of a step, check it off so you will not lose your place and omit an operation.

All illustrations are grouped at the end of this manual. You should remove them, so that each illustration can be kept before you as long as you need it.

Figs. 4 and 5 are reproductions of the printed board, which you may find useful now or in case servicing is necessary. One good use for Fig. 4 is checking for solder bridges. Once in a while someone piles so much solder on a connection that it overflows and goes across the insulating material to another copper line or circle, forming a connection not intended. When you see solder connecting two points on the board, check with Fig. 4. If there is copper under the solder, all is well. If not, take away the solder connecting the two points with a dry iron.

## TR-3D AND TR-3M DIFFERENCES

These instructions cover both the 1-channel and 2-channel versions of the TR-3. Certain operations are to be done on one but not on the other.

Where you see **1-channel only** at the start of a step, just after the step number, follow that step only if you have the TR-3M 1-channel amplifier. If yours is the TR-3D 2-channel amplifier, ignore that step and go on to the next one.

If you see **2-channel only**, follow the step only if yours is the TR-3D 2-channel amplifier. If you are making a 1-channel amplifier, ignore that step and go on to the next one.

To avoid any errors, it is a good idea to go through the steps now and plainly cross out any that do not apply to you.

## PRINTED CIRCUIT ASSEMBLY

If yours is the 2-channel amplifier, you have two identical printed circuit boards 11507. They are to be assembled identically. You can do it in one of two ways. Either go through the board assembly steps with one board, then go back to step 1 and repeat them all for the second board—or follow each step twice, once for each board.

If you do the latter, remember not to check off the square preceding each step number until you have performed the operation on *both* boards. Or—probably a surer method—make a check mark for each board so you will have two marks for each step.

☐ 1. Remove your board from its wrapping or envelope. Treat it with some care, remembering that a scratch through a copper line could destroy the electrical continuity of the line.

☐ 2. Install ½-watt resistors as follows. For each resistor value, the first figure gives the quantity, the second gives the resistor value and color-band markings, and the remaining numbers are those of the outlines over which the resistors go.

8 **100 ohms (brown-black-brown)** at 15, 16, 39, 40, 41, 60, 68, 69.
2 **1200 ohms (brown-red-red)** at 58, 59.
2 **1500 ohms (brown-green-red)** at 37, 38.
1 **220 ohms (red-red-brown)** at 73.
1 **2700 ohms (red-purple-red)** at 47.
1 **47 ohms (yellow-purple-black)** at 17.
3 **470 ohms (yellow-purple-brown)** at 62, 63, 75.
2 **4700 ohms (yellow-purple-red)** at 2, 4.
3 **560 ohms (green-blue-brown)** at 44, 45.

☐ 3. Bend the wires of two 22-ohm (red-red-black) *1-watt* resistors in the usual way. On the right end of the *copper* side of the board, find two holes, each labeled 70 in copper. With the body of a 22-ohm resistor on the *copper* side of the board, pass the wires through the 70 holes and press the resistor down as close to the board as possible. Note that this resistor, unlike the others, is on the copper side, its wires protruding from the painted side. Solder the wires to the copper circles. Then clip off the excess on the painted side.

☐ 4. In exactly the same way, mount the second 22-ohm resistor on the copper side of the board in holes 71.

**NOTE:** In the next step you will be told to open a MATCHED RESISTORS envelope. Do not mix any of the resistors in it with your remaining loose resistors. If you are doing two circuit boards, you have two such envelopes. Assign one envelope to each board and use the designated resistors in it on one board only.

When you are told to open the 1% RESISTORS envelope, handle them, if you have two, in the same way.

☐ 5. Open the MATCHED RESISTORS envelope. Install resistors from it as follows. Then close the envelope to keep the remaining resistors in it segregated.

4 **1,000 ohms (brown-black-red)** at 13, 14, 27, 28.
2 **100,000 ohms (brown-black-yellow)** at 9, 10.
2 **1500 ohms (brown-green-red)** at 23, 24.
2 **22,000 ohms (red-red-orange)** at 29, 30.
2 **560 ohms (green-blue-brown)** at 20, 21.

☐ 6. Open the 1% RESISTORS envelope and install resistors as follows.

2 **110 ohms (brown-brown-brown)** at 64, 65.
2 **240 ohms (red-yellow-brown)** at 56, 57.

☐ 7. Put one of your wooden dowels on a very firm surface, one flat end down. Into the approximate center of the upfacing flat surface drive a wire brad (thin "headless" nail—not shown in a drawing). Hammer it in just far enough so it is firmly in and will not come out. Try to keep it as straight as possible. Then clip off enough of the brad so that exactly ¼ inch remains. (There is a spare brad in case you bend one.)

☐ 8. Put the open end of a tubular terminal (Fig. 2-A) over the brad, pushing it on until the open end is against the wood.

☐ 9. Hold the circuit board in your lesser hand (left hand if you are right handed, or *vice versa*). Flatten your hand to support it fully, with the painted side up.

☐ 10. Pick up the wood dowel with the point of the tubular terminal down and put the point down into the board hole marked B+. Press it down firmly, keeping the terminal perpendicular to the board, until the terminal is in the hole as far as it will go—until the bulge which runs all the way around, just below the tubular portion, is down against the painted surface of the board. Then withdraw the dowel, straight up. The terminal will stay in the hole and the brad will be free for the next terminal insertion.

☐ 11. In exactly the same way insert tubular terminals in holes PC, PB, OT, NB, B–, F1, F2, IN, and GND, all with their open ends on the painted side and their points visible on the copper side.

☐ 12. Now turn the board over so the *copper* side is up. Insert terminals in holes D1, D2, and D3. These have their open ends on the copper side and the pointed ends are visible on the painted side—the reverse of the first 10 terminals.

☐ 13. Use pliers to pull the brad out of the dowel, and throw the brad away. (If you are assembling two boards, do this only after finishing the second board.) Keep the dowel.

☐ 14. Solder all 13 terminals to the copper, counting as you go to make sure you have soldered 13. You will probably find that the terminals seem to "drink up" the solder and more solder is required to make these connections than for the usual wires and terminals. This is as it should be, for the solder is going inside the terminals, filling them up. Use whatever amount of solder is necessary from your supply so that the connections to the copper look like the usual connection.

☐ 15. Now look at the open end of each terminal. It should be filled with solder right to, or almost to, the brim of the open end—but there should not be a big glob of solder outside the end. If it is not filled, heat the side of the terminal and feed solder inside it. If it is overfilled, let the hot iron take the excess away. Count again, to be sure all 13, on both sides of the board, are soldered and solder-filled.

☐ 16. Open the SPECIAL DIODES envelope. The eight diodes may be bullet shaped (like outline 8 and others on the board) or cylindrical, made of glass or an opaque material. Each one has a *cathode end* which you must identify.

If the diode is bullet shaped, the cathode end is the *small* end.

If the diode is cylindrical, one end has a special marking which does not appear at the other end. The marking is usually a dot or a band, but it could be something else. The other end is unmarked. The cathode end is the marked end.

**SPECIAL NOTE**: In a glass diode there is often some colorful part at one end *inside* the glass. Ignore that. The marking that counts is on the *outside.* Look very closely to be sure you identify the *outside* marking.

☐ 17. On the painted side of the board, install the eight diodes over outlines 5, 6, 7, 8, 31, 32, 33, and 34, with the cathode end of each diode at the *small end of the outline.* It is highly important that you turn each diode the right way. For example, at outline 34, you would install the diode with the cathode end (defined in step 16) pointing at the 11507 marking near the bottom edge of the board.

☐ 18. Hold a small transistor socket (left socket in Fig. 2-B) with the three terminals down. Pass them down through the three holes inside outline 11. Press the bottom of the socket flat against the painted surface of the board. Turn the board over. If the socket does not stay in position, press it against the board and bend the terminals slightly outward on the copper side to hold it. Solder each terminal to the copper.

☐ 19. In the same way, install sockets at outlines 12, 18, 19, 35, 36, 42, 43, 54, 55, 66, and 67. If you choose to place the sockets first and then solder them all at once, count as you solder to be sure you have soldered three terminals for each socket. It is easy to miss one otherwise. The total number of sockets is 12, a total of 36 terminals.

☐ 20. Open the MATCHED RESISTORS envelope and remove the remaining four resistors. Install one 680-ohm (blue-gray-brown) resistor in the holes marked 48 on the *copper* side of the board, and the other 680-ohm resistor in holes 49. Note that the bodies of these resistors are on the copper side like those in holes 70 and 71 (steps 3 and 4).

☐ 21. Bend the wires of a 270-ohm (red-purple-brown), 2-watt resistor from the envelope in the usual way and insert them in the holes marked 52 in copper, the resistor body again on the copper side of the board. As you push the resistor toward the copper face of the board it will encounter the body of the resistor in holes 48. When this happens, pull the resistor toward the bottom edge of the board, bending its wires so it clears the lower end of resistor 48 and lies against the board. Then solder the wires and clip them off where they emerge on the painted side.

☐ 22. Install the second 270-ohm resistor in holes 53, treating it the same way to get it past the end of resistor 49.

The MATCHED RESISTORS envelope should be empty.

**NOTE**: Before installing each disc or mylar capacitor (Fig. 3) look closely at its wires just where they emerge from the capacitor body. These capacitors have been dipped in a coating material and sometimes far enough so the coating is on a portion of the wires. To take solder, the wires must be perfectly clean. So if you find any coating on the wires, clean it off before installing the capacitor. It can be scraped off with a blade.

☐ 23. Install three disc capacitors on the painted side of the board, as follows.

**47 pf** over outline 3.

**.001 mfd** in outline 22.

**.003 mfd** in outline 61.

☐ 24. Install a .0022-mfd mylar capacitor in outline 46.

☐ 25. Install a 10-mfd, 35-volt, nonpolarized electrolytic capacitor in outline 1. (It makes no difference which way this capacitor is turned.)

**NOTE**: The electrolytic capacitors which follow have one end which is marked +. There is usually a circular depression around the + end of the capacitor. The + mark itself may not be near an end of the capacitor. It may simply be at one end of the lettering on the unit. If you hold the capacitor horizontal and the + is at the right end of the lettering, it is the right end of the capacitor which is + or positive. It is import-

ant to know which is the + end and to install each capacitor with that end placed as instructed.

☑ **26.** Install the 2500-mfd, 3-volt electrolytic capacitor in outline 72, turning it so its + end corresponds with the + marks in one end of the outline and at the hole for the wire.

☑ **27.** Hold the 1,000-mfd, 3-volt electrolytic capacitor vertical with its + end down, as in Fig. 6. Bend over the top wire as shown. Insert the + wire into the hole in the center of outline 74 and the bent wire into the hole just right of outline 74, to which a short line goes from the outline. Notice that the center hole is marked +, telling you which wire remains straight and goes inside the circle, and the hole for the remaining, bent wire is connected to the circle by a short line and has no + mark.

☑ **28.** Hold the capacitor with its end squarely against the painted surface of the board. On the copper side, bend the wires slightly away from each other so the capacitor will not fall out when you turn the board over.

☑ **29.** Turn the board over and solder the *straight wire* only.

☑ **30.** On the painted side, straighten the capacitor if necessary. Then solder the bent wire and clip off the excess of both.

**NOTE**: All remaining electrolytic capacitors are installed with this same technique. The wire which remains straight and goes inside the circular outline is the + one *if the + sign is inside the circle.* If the + mark is at the hole which is outside and connected to the circle by a painted line, then the + wire is the one which is to be bent over and inserted in the outside hole. *Be very careful to get this right each time.*

☑ **31.** Install electrolytic capacitors as follows.

**100 mfd, 25 volts** at 50, + end up.

**100 mfd, 25 volts** at 51, + end down.

**47 or 50 mfd, 25 volts** at 25, + end up.

**47 or 50 mfd, 25 volts** at 26, + end down.

☑ **32.** With the aid of Fig. 2-A, select four spacers, four 2-56 X 3/16 round-head machine screws, and four No. 2 lockwashers.

☐ **33.** Hold the board flat, painted side up. Pass a screw up through one hole marked S. On the painted side of the board put a lockwasher over the screw. Then wind a spacer onto it, finger-tight. Use a screwdriver to tighten the screw firmly.

☐ **34.** Repeat step 33 for the remaining three S holes.

☐ **35.** Use Fig. 2-B to identify, and locate, one each 40409 and 40410 transistors. They look alike but differ in the number printed on each transistor. Notice that two metal tabs protrude (in the same direction as the transistor wires) from the heat radiator to which each transistor is attached. Clip these tabs off.

☑ **36.** Clip off the wires of each transistor so just ¼ inch of each wire remains. Straighten each wire carefully with long-nose pliers.

☑ **37.** Hold the 40409 transistor over socket 67. See that the pattern of the wires matches the holes in the socket. Insert the wires carefully into the socket holes and gently but firmly press the whole affair down so the wires go into the socket until stopped by the heat radiator's hitting the tops of the spacers. Rotate the transistor slightly as necessary until the holes in the heat radiator are directly over the holes in the spacers.

☑ **38.** Drop a 2-56 screw into each radiator hole and into the spacer holes below. Then use a small screwdriver to tighten each screw firmly. The screws will stay in place better when you drop them (with tweezers or small pliers) if you first raise the transistor about 1/16 inch. Tightening the screws will then push the transistor back down into place.

☑ **39.** In exactly the same way, install the 40410 transistor in socket 66.

☑ **40.** Check again to see that the 40409 is at 67 and the 40410 is at 66.

☑ **41.** Straighten the wires of your three 2N2102 transistors (read the markings to be sure) and clip off all but ¼ inch. Insert them all the way into sockets 54, 43, and 35.

☑ **42.** Prepare the wires of the three 2N4036 transistors in the same way and install them at 55, 42, and 36.

☑ **43.** Your 045000 and 045500 transistors may look like either of the two illustrations in Fig. 2-B—round metal case or D-shaped epoxy case, either one much smaller than the transistors you just installed. Read the markings very carefully to be sure you have an 045000 or 045500 as called for.

☑ **44.** Pick up an 045000. Cut the wires down to about ¾ inch (if they are not already about that long).

☑ **45.** Spread the wires apart until their ends correspond to the positions of the holes in a transistor socket. Be very careful to see that the pattern of the wires is retained. Then carefully but firmly insert the wire tips into the holes of socket 12 and press the transistor down firmly, holding it with thumb and second finger to be sure it goes down straight. Press it in as far as possible, but note that these transistors will not go all the way down to the sockets as the previous ones did.

☑ **46.** Install a second 045000 in socket 18 and the two 045500's in sockets 11 and 19. Read each transistor number.

☑ **47.** Put a small finned heat sink (Fig. 2-B) on top of transistor 54. Support the board with the other hand right under the transistor. Press the heat sink down so it goes over the transistor. You may think its center hole is too small until you notice that it can expand. Rock the sink slightly if necessary until it starts down over the transistor. Press it as far down as it will go.

☑ **48.** Put the other heat sink on transistor 55.

☑ **49.** The printed board is now complete. Check it over in great detail. This is especially important in a power amplifier because an error could destroy power transistors.

Look over the copper side very closely and in good light. See that there are no unsoldered connections. See that all connections look good—enough solder, the solder blending smoothly into the wire or terminal and the copper. (If any look suspicious, reheat them and add a tiny bit more solder.) Clip off any excess wire you overlooked—but do not clip off the three tubular terminals with open ends on the copper side nor the points of the other tubular terminals.

Refer to Fig. 4 to see that wherever solder connects to copper lines or circles there is copper under the solder.

See that the electrolytic capacitors are turned the right way, consulting step 31. See that the diodes are turned the right way, small ends or marked ends toward the small ends of the bullet shaped outlines.

☑ **50.** If yours is a 2-channel amplifier and you have done only one of the two circuit boards, begin again at step 1 and do the second one.

## ASSEMBLING THE FRONT PANEL

☑ **51.** Put a folded newspaper on your work table to protect the front panel from scratches. Then peel away the pro-

tective material from the lettered side of the panel and put it on the newspaper, lettered side down. Turn it so you see the pattern of holes as in Fig. 7.

☐ 52. Use a felt pen of the "permanent" kind, which will mark on metal, to reproduce on your panel rear the hole identification letters you see in Fig. 7. Note that letters go from A through P, omitting I and O.

☐ 53. Your circuit breaker is a rectangular part with a red pushbutton. The circuit breaker mounting plate is a plastic flat piece with a large threaded bushing at its center. Find both, plus a nut, lockwasher, and flat washer that fit the bushing. (Plate and hardware may be in an envelope labeled CIRCUIT BREAKER MOUNTING HARDWARE, may all be separate, or may be mounted on the circuit breaker.

☐ 54. Put the plate against the front of the breaker, bushing outward, the red button passing through the bushing and the metal tabs at the two ends of the breaker going through the slots near the plate ends. Hold the plate flat against the breaker and bend over the metal tabs, inward, against the face of the plate, to hold the plate firmly to the breaker.

☐ 55. Put the lockwasher over the bushing. Then pass the bushing through hole A in the panel. On the lettered side, put the flat washer, then the nut on the bushing. Turn the breaker so the terminals on its back are positioned per Fig. 8. Then tighten the nut firmly enough so the breaker is obviously adequately attached but you are not in danger of cracking the plastic.

☐ 56. Identify the power switch by comparing its rear with the switch drawing at holes B and C in Fig. 8. Pass its front through the rectangular cutout from the panel rear, so its mounting tabs are on the panel rear, over holes B and C. See that it is turned so the terminal pattern is as shown. Fasten it to the panel with two 6-32 × 3/16 pan-head machine screws through the panel front into the threaded holes in the mounting ears.

☐ 57. **1-channel only.** Press the four 3/8-inch hole plugs (Fig. 2-A) into holes H, J, D, and E from the front of the panel, and the 1/4-inch plug into hole M. Press all plugs in all the way so their circular tops are right down against the metal of the lettered side of the panel.

☐ 58. Remove two nuts, the metal flat washer, and both plastic washers from a red binding post (Fig. 2-B). Look at both plastic washers. Notice that both have D-shaped shoulders that will fit into hole F, but only one also has, in its other face, a hex-shaped socket into which what is left of the binding post itself will fit.

☐ 59. Hold the panel horizontal, lettered face up, with a finger behind hole F so you can identify hole F from the front. Pick up the plastic washer that has the hex socket and place it in hole F, turning it so the D-shaped shoulder coincides with the D shape of hole F and actually goes inside the hole.

☐ 60. Pick up the red binding post. Turn it so that the hole in its brass core, revealed when its cap is unwound as far as possible, runs horizontal with respect to the panel. Then place the brass part into the washer. The hexagonal part of the post fits into the hex socket of the washer. As long as the D of the washer remains in hole F and the hex part of the post remains in the hex socket of the washer, the post is prevented from turning and the hole in its core must remain horizontal. This is the condition you want to preserve or restore, whatever may be your fumblings in completing the installation of the post.

☐ 61. Holding post and front washer in place as specified, put the second plastic washer over the brass screw of the post where it emerges on the back of the panel, the D shoulder toward the rear face of the panel. Fit the shoulder of the washer into the D shape of hole F on the panel rear. Make sure the shoulder is actually inside the hole so the washer cannot move or rotate.

☐ 62. Add the flat metal washer and *one* nut, running it up to the rear plastic washer but not tightening it. Look very carefully to see that (a) both plastic washers appear to be right up against their respective surfaces of the panel, indicating that the D shoulders are fitted to and inside the D shape of hole F, and (b) the hole in the stem or core of the post is still horizontal. Then tighten the nut firmly enough to assure a good fastening but not with enough strength to crack the plastic.

☐ 63. Following steps 58 through 62 again, install a *black* binding post in hole G.

☐ 64. **2-channel only.** In exactly the same way, install a red binding post in hole D and a black one in hole E.

☐ 65. Put a solder lug over the screw of each binding post on the back of the panel, on top of the nut. Add the second nut. Turn each solder lug so it faces as shown in Fig. 8; then tighten the nut firmly. (Fig. 8 shows components installed for the 2-channel amplifier. If yours is 1-channel, you will have hole plugs in holes M, H, J, D, and E instead of the items shown.)

☐ 66. The end of each solder lug is already bent to an angle away from the panel. Bend the ends of lugs G and E more, so the small end of each of these two lugs points almost directly away from the panel.

☐ 67. Mount a 2-terminal tie point on the rear of the panel with a 4-40 × 1/4 pan-head machine screw, nut, and lockwasher through hole P. The screwhead is on the lettered side and the lockwasher is under the nut. Before tightening, turn the tie point to the position shown.

☐ 68. Fig. 2-B shows a phono jack, with its hardware—a thin flat washer, a solder lug, and a nut. Locate one or two sets in your kit, depending on whether you have a 1- or 2-channel amplifier.

☐ 69. Pass the threaded part of a jack through hole N from the panel front so the threaded part shows up on the rear. Add the solder lug, then the flat washer and nut. Tighten the nut, while holding the solder lug so it points at the top edge of the panel as Fig. 8 shows. If you should find it necessary to hold the front of the jack to prevent it from turning, grasp it with padded gas pliers and don't mar the panel.

☐ 70. Slip a knife blade between the solder lug and the panel and pry it up. Then grasp the end with pliers and rotate it enough so that a horizontal wire can be passed through it.

☐ 71. **2-channel only.** Follow steps 69 and 70 again to mount a second jack in hole M.

☐ 72. Your kit contains two kinds of potentiometers (the items shown in holes K, L, H, and J in Fig. 8). One type has a plain metal shaft. The other has a short, probably plastic shaft, with knurled edge and a screwdriver slot.

Put a lockwasher over the threaded bushing of a potentiometer with the longer, plain shaft. Pass shaft and bushing through hole K from the rear of the panel. On the lettered face, put a flat washer and a nut on the bushing. Tighten the nut firmly, holding the potentiometer body so the three terminals point straight up, as shown in Fig. 8.

☐ 73. Mount a potentiometer with a screwdriver-slot shaft in hole L in the same way, but with its terminals pointing toward the panel center per Fig. 8.

☐ 74. **2-channel only.** In the same way, install a second plain-shaft potentiometer in hole H and a second one with the very short screwdriver-slot shaft in hole J. See that the terminals of each point as shown in Fig. 8.

## WIRING THE FRONT PANEL

All front panel wiring is shown in Fig. 9—but use the drawing only to confirm your understanding of the instruction text; do not wire by following the drawing alone.

Connection terminals are usually referred to by the number of the hole in which the item is mounted, plus, if appropriate, the terminal number shown in Fig. 9.

When you are told to "prepare" a wire, cut the wire specified to the length given and remove ¼ inch of insulation from each end—unless instructed otherwise. If the wire is stranded, twist the strands tight and tin by applying a very thin coat of solder to hold the strands together and form a solid wire.

When connecting a wire to a terminal, make a mechanical connection first. Where there is a hole in the terminal, bend the end of the wire into a hook, hook it in the hole, and squeeze the hook tight shut with pliers. Where there is no hole, hook the wire *around* the terminal and squeeze.

Solder every connection immediately—unless you are specifically told not to.

**WARNING:** You will have trouble later only if you get careless now. Make every connection and every solder joint with loving care, rereading the instruction more than once to be absolutely sure you understand it. There are few things more irritating in life than blowing a power transistor and finding you did it because of carelessness or inattention during assembly.

In this and succeeding portions of the job, it is perfectly all right to use a conventional 60- to 100-watt soldering iron if you wish, to be sure you heat every joint enough so the wires and terminals are really hot. It is by no means necessary to do so, however. Your small pencil iron will do everything if you make sure you hold it in place long enough actually to see with your own eyes that the solder flows freely and blends perfectly into every wire and terminal. (We do not recommend soldering *guns* for this kind of work. They take time to heat every time you pick them up—and sometimes you may not wait long enough to get maximum heat!)

☐ 75. Cut the wires of a 10-mfd, 35-volt, nonpolarized electrolytic capacitor down to about ⅞ inch. Connect it between K-6 and the terminal *at the center* of jack N. *Solder only at K-6.* Press the capacitor body against the back of potentiometer K.

☐ 76. **2-channel only.** Install the other 10-mfd nonpolarized capacitor between H-3 and the center terminal of jack M in the same way. *Solder only at H-3.*

☐ 77. Prepare 4½ inches of purple wire. Connect one end to K-5.

☐ 78. **2-channel only.** Prepare a 5½-inch purple wire and connect one end to H-2.

☐ 79. Straighten your bare wire by clamping one end in a vise and pulling on the other end with pliers until you can feel the wire stretch slightly. Clip off and discard the ends that were in the vise and pliers. Do not let this wire get kinked from here on.

☐ 80. **2-channel only.** Cut 2½ inches of bare wire. Pass one end through the solder lug (not the center terminal) of jack M, the solder lug of jack N, and K-4. Bend and clinch a hook at K-4. Solder at all three points. Then clip off excess wire to the left of the jack M solder lug.

**NOTE:** This wire will now be referred to as the *jack ground wire.* When soldering other wires to it, hook and clinch them around it at the approximate locations shown.

☐ 81. **1-channel only.** Pass a 2½-inch piece of bare wire through the solder lug (not the center terminal) of jack N and K-4. Hook and clinch it at K-4. Solder at both points. Then clip off the wire so that 1 inch of it remains to the left of the jack N solder lug.

**NOTE:** See note following step 80.

☐ 82. **2-channel only.** Prepare a 3½-inch piece of the *thinner* black wire. Connect it between H-1 and the jack ground wire. Press it down against the panel.

☐ 83. Connect a 1-megohm (brown-black-green) resistor between the center terminal of jack N and the jack ground wire. When you solder to the jack center terminal—soldering also the capacitor wire already there—hold the panel vertical, to prevent any solder from running inside the jack.

☐ 84. **2-channel only.** Install a second 1-megohm resistor between the center terminal of jack M and the jack ground wire in the same way.

☐ 85. Prepare 6½ inches of the *thinner* black wire. Connect one end to the jack ground wire.

☐ 86. **2-channel only.** Connect a second 6½-inch thin black wire to the jack ground wire.

☐ 87. Cut 11 inches of the *heavy* black wire and strip each end of ⅜ inches of insulation. Connect one end to the jack ground wire.

☐ 88. Prepare 6½ inches of gray wire, stripping one end ½ inch instead of ¼. Pass the ½-inch end through L-7 and L-8, hooking and clinching it at L-8. Solder at both points.

☐ 89. **2-channel only.** Prepare a second, identical gray wire. Pass the ½-inch end through J-10 and J-11, clinching a hook at J-11. Solder at both terminals.

☐ 90. Prepare a 6½-inch gray wire. Connect one end to L-9.

☐ 91. **2-channel only.** Connect one end of a second, identical gray wire to J-12.

☐ 92. Cut the wires of a 10-ohm (brown-black-black), 2-watt resistor down to ¾ inch. Pass one wire through the P-14 hole nearest the panel (the hole that also goes through the insulating strip) and the other in the hole nearest the binding post of solder lug F. Hook and clinch the wire at F. Solder at both points, but do not fill the end hole of lug F with solder.

☐ 93. **2-channel only.** Install a second 10-ohm resistor in the same way between P-13 and D.

☐ 94. Cut the wires of a .22-mfd mylar capacitor down to ¾ inch. Connect the wires to the hole nearest the binding post of lug G and the upper part of P-14. After soldering at both points, bend the capacitor wires so the capacitor stands straight away from the panel. (Do not fill the end hole of lug G with solder.)

☐ 95. **2-channel only.** Install a second .22-mfd capacitor in the same way between lug E and P-13.

☐ 96. Prepare a 6½-inch piece of *heavy* black wire, striping one end ½ inch instead of the usual ¼ inch. Connect the ¼-inch end to the end hole of solder lug G.

☐ 97. **2-channel only.** Use a 2¾-inch piece of bare wire to connect together the tips of the brass portions of binding posts E and G. Wrap the wire tight around each brass tip and

clinch with pliers. Apply plenty of heat so the brass is hot enough to cause the solder to flow over it with enthusiasm. (Notice that there is a sort of round depression in the brass near the tip; that is where the wires should go.)

☑ **98.** Your a.c. line cord has the standard 2-prong plug at one end. At the free end, pull the two wires apart for several inches. Cut off 2 inches of one wire. One end is already stripped; strip the other. Connect the wire between A-19 and B-16.

☑ **99.** Check all connections on the front panel to see that they are well soldered.

☐ **100.** See that everything corresponds to Fig. 9. (If your amplifier is 1-channel, of course, items M, H, J, D, and E and all associated wiring, as well as one of the thin 6½-inch black wires at the top will be missing.

## ASSEMBLING THE REAR PANEL

☑ **101.** Put some newspaper on the table. Then put your rear panel on the paper, black side down, turned so the hole pattern looks like Fig. 10. Mark the hole letters on the metal.

☑ **102.** Find your rectifier, which looks like the circled inset in either Fig. 11 or Fig. 12, and your colorless capsule of grease.

**NOTE:** You will use the grease to coat the flat surface of the rectifier and both sides of four power transistor insulators, a total of nine surfaces about the size of the flat rectifier face. You need, therefore, to be sparing with it. The best way to dispense it is to lay the capsule, flat side down, on the table, then cut a small slit horizontally at one point in the circumference at the base of the round part. When you need grease, you pick up the capsule, squeeze it gently, and take the requisite amount of grease on the tip of your little finger. The slit will close when you stop squeezing.

It is important not to get any particles of grit or dirt in the grease or on any surface you grease. So when you store the capsule between uses, do so in a clean place.

☑ **103.** Wipe off the area of the back panel to be occupied by the rectifier and also the flat, nonterminal face of the rectifier itself. Then, with the tip of a *clean* finger, apply a thin film of grease to the flat rectifier face. The grease must cover the entire surface of the rectifier—no dry spots. There is no particular virtue in making the film as thin as possible, as long as you don't use more than ⅓ of the grease in the capsule.

☐ **104.** Lay the rectifier down, on its terminals. Wipe your hands thoroughly to get rid of all grease.

☑ **105.** If yours is the rectifier shown in Fig. 11, place it, flat, greased side down, on the nonblack face of the rear panel so that (a) the holes in its mounting ears are over holes A and B and (b) the terminal with the red dot is positioned as shown. Then use two *black* 6-32 X ½ machine screws and two 6-32 nuts and No. 6 lockwashers to fasten it tightly to the panel. The screwheads go on the black face of the panel, and the lockwashers go under the nuts.

☐ **106.** If your rectifier is like that in Fig. 12, lay it on the panel with (a) its center hole over hole E and (b) the red-dotted terminal placed as shown. Fasten it with a 6-32 X ¾ round-head screw through hole E and the rectifier center, the screwhead on the black face of the panel, a No. 6 lockwasher and 6-32 nut on the terminal face of the rectifier. Tighten firmly.

**NOTE:** The purpose of the grease and the tight screws is to assure the best possible physical contact between the flat face of the rectifier and the panel. The heat generated by the rectifier will then be transmitted to the panel, whose relatively large surface area will dissipate it efficiently to the outer air. The same will be true of the large power transistors you will install later, though in their case an insulator will be interposed between each transistor and its panel; greasing both sides of the insulator and mounting the transistors tight will do the same job of aiding heat transmission.

☑ **107.** If you have accidentally gotten grease on anything or put so much grease on the rectifier that it has squeezed out, wipe it away thoroughly.

☑ **108.** Use a black 6-32 X ½ machine screw and nut to fasten a solder lug to hole G, with the screwhead on the black side of the panel. No lockwasher is necessary. When you tighten the screw hold the solder lug with its end facing as shown in Fig. 11 or 12.

☑ **109.** Insert the rubber grommet into hole F. Ordinarily you can do it with your fingers; if it is stiff it helps to wet it with water. But if you use a tool to help, don't damage the grommet. Be sure it is in all the way and looks the same on both sides of the panel.

☑ **110.** When you set this panel aside see that its black surface does not get scratched.

## ASSEMBLING THE TRANSFORMER CHASSIS

☑ **111.** Your power transformer is the heaviest object in the kit. Put it on the table upside down, the hole from which the two black, two red, and one yellow wires emerge facing up. Turn the transformer so the wire hole is farthest from you.

☑ **112.** Identify the transformer chassis from Fig. 13. Hold it horizontal with its flanges up and mark on it the hole letters. Then lower it onto the transformer so the wires come up through hole A. Line up holes B, C, D, and E over the elongated holes in the transformer mounting feet.

☑ **113.** Put a lockwasher over a 10-32 X ⅜ machine screw and pass the screw up through the transformer foot and hole B. Add a 10-32 nut and run it down very loosely. Do the same with the remaining three transformer feet and holes C, D, and E.

☑ **114.** Move the chassis until its edge shown at the top of Fig. 13 is about even with the edges of the transformer feet. Then use a nutdriver to tighten all four nuts just as firmly as you can. (Don't use a screwdriver on the screws.)

☐ **115.** Identify your 6,000-mfd can electrolytic capacitors from Fig. 3 and the two capacitor clips from the bottom part of Fig. 14.

☑ **116.** Slide a clamp over one capacitor from the nonterminal end, loosening the clamp screw as necessary for the purpose, with the clamp's mounting ears nearest the terminal end of the capacitor. Slide it all the way to the terminal end. Tighten the screw just enough so you can still rotate the clamp on the capacitor and slide it up and down the capacitor, but so it will not move unless you purposely move it.

☑ **117.** Turn the capacitor so the terminals face you as you see them on capacitor F at the bottom of Fig. 14—the red-dotted terminal at your right. Rotate the clamp so it is as shown at the bottom of Fig. 14 for capacitor F (*don't* look at G). Notice that a line drawn through the bases of the terminals would also pass through the holes in the clamp mounting ears. And notice that the clamp screw is nearer the undotted terminal. See that the clamp is tight enough so it won't move accidentally when you pick up the assembly. However, you

must still be able to move it purposely.

☐ 118. Pick up the assembly and position it under hole F, with the clamp mounting ears under holes H and J, and the capacitor turned so the red dot is where shown. Fasten the clamp to the chassis with two 6-32 X ½ *round-head* machine screws, lockwashers, and nuts. Put the lockwashers on the screws first, pass the screws up through the holes, add the nuts, and tighten with a nutdriver.

☐ 119. Looking at the assembly from the edge, slide the capacitor toward the chassis until it touches. Then move it down, away from the chassis about 1/16 inch. The distance is not critical as long as the capacitor case does not actually touch the chassis.

☐ 120. Now tighten the clamp screw so the capacitor is definitely imprisoned and cannot move—but not so much as to deform the clamp.

☐ 121. Put the second clamp on the second capacitor in the same way, but notice that for capacitor G it is rotated to a different position. Again a line passing through both terminal bases would also pass through the clamp ear holes—but this time the clamp screw is nearest the red-dotted terminal.

☐ 122. Mount this assembly over hole G, fastening the clamp ears to holes L and K with 6-32 X ½ round-head machine screws, nuts, and the lockwashers under the screw-heads. Again, push the capacitor end against the chassis, then back it off about 1/16 inch before tightening the nuts. See that the red-dotted terminal is where shown in Fig. 14.

☐ 123. Put a No. 6 lockwasher over the end of the screw in hole J. Add the mounting foot of a single tie point (Fig. 2-B), then a 6-32 nut. Turn the tie point to the position shown in Fig. 14 when you tighten the nut. If your letter J marking is not still entirely visible, make a new J.

☐ 124. Find all the plastic cable clamps in the kit and divide them into two groups—large and small. You can compare sizes (which are not terribly different) by pinching together the holed ends of two clamps, one in each hand, and comparing the sizes of the loops. Also, the small ones may be marked ¼ and the larger 5/16 with letters molded into the plastic, but that is pretty hard to read. Label the groups. From now on we will refer only to "larger" and "smaller" plastic cable clamps.

☐ 125. Put a ½-inch-diameter flat washer on the screw in hole K. Put both holes of a *larger* cable clamp over the screw, flat side of the clamp down. Add a second flat washer, then a solder lug, and finally a 6-32 nut. Turn the clamp so its loop is at your left and the solder lug so it points to your right. Hold them so as you tighten the nut.

## WIRING THE TRANSFORMER CHASSIS

Fig. 15 shows all the wiring you will do on the transformer chassis. Check continually to see that everything you do agrees with the drawing. Where you connect only one end of a wire, lead it away from the connection as shown.

As before, solder every connection when you make it unless specifically instructed otherwise.

☐ 126. Notice in Fig. 15 the bare jumper wire between the red-dotted terminal of capacitor G and the undotted terminal of capacitor F. The same jumper is shown in Fig. 16, this time with the viewer looking directly at the lower edge of the chassis. Note that the wire runs straight up from one terminal for about ¾ inch, over to the other terminal, then directly down to it. Use a 4⅛-inch piece of your bare wire. First bend over ¼ inch at one end and hook that into one of the terminals; squeeze the hook shut and solder, with the end of the wire going straight up. Then bend the wire so it runs to the other terminal, bend it down to the terminal, make a ¼-inch hook, hook it into the terminal, squeeze, and solder. Make all bends sharp, using pliers. The main part of the wire, which is about 2⅛ inches long, should be approximately parallel to the chassis surface, as shown, and about ¾ inch above both *terminals* (not ¾ inch above the chassis). Be sure you have selected the right terminals. Precision is not important; just see that you conform with the general idea.

☐ 127. Now push the jumper at point A (Fig. 16) toward the nearby bottom edge of the chassis and simultaneously push point B in the opposite direction, so that the wire runs about parallel to the bottom chassis edge as it is shown in Fig. 15.

☐ 128. Prepare a 2-inch piece of thin black wire. Connect one end to the end hole of solder lug K and the other to the bare jumper wire.

☐ 129. Cut both red transformer wires so 2½ inches of each remains above hole A. Strip the end of each ¼ inch. *Save both cut-off pieces.*

☐ 130. Cut one saved piece of the red transformer wire down to 8½ inches and the other down to 4 inches. One end of each is already stripped. Strip the other end of each ¼ inch. Then connect one end of *both* wires to the red-dotted terminal of capacitor F.

☐ 131. Pass the free end of the 4-inch piece through the lower end of the terminal on tie point J. **WARNING:** This does *not* mean the lowest hole in the tie point, where the mounting foot is fastened to the brown insulating material. Connecting it there would cause an electrical connection to the chassis itself, which is *not* intended. You should pass the stripped end of the wire through the hole by which the *terminal* is fastened to the insulating material, causing electrical connection only to the terminal, not to the chassis.

☐ 132. Fill this hole, with the wire in it, with solder, using plenty of heat so the solder flows into the terminal metal and the wire for a good joint. Then press the wire down against the chassis out of the way.

☐ 133. Twist the lengths of the two black transformer wires together to make a twisted pair. Lead them straight down the chassis and over the red wire just installed, and through the cable clamp. Pull out all slack, clip both wires 3½ inches below the chassis edge, and strip both of them ¼ inch.

☐ 134. Cut the yellow transformer wire down to 5¾ inches and strip the end ¼ inch. *Save the cut-off piece.* Connect the end of the 5¾-inch length to the bare jumper wire.

☐ 135. Strip the cut end of the yellow wire clipped from the transformer ¼ inch. Connect, but *do not solder,* to the *un*dotted terminal of capacitor G.

☐ 136. Prepare two 7-inch pieces of yellow wire. Connect one end of each wire to the undotted terminal of capacitor G. Then solder all three wires to the terminal.

☐ 137. Prepare 6 inches of the *thin* black wire. Connect one end to the bare wire jumper.

☐ 138. Prepare 8 inches of red wire, stripping one end ⅛ inch and the other the usual ¼ inch. Connect the ¼-inch end to the upper part of tie point J, but *do not solder.*

☐ 139. Prepare 6½ inches of red wire in the same way and connect the ¼-inch end to terminal J. Now solder both red wires to terminal J, but do not fill the hole with solder, as another wire will be connected there later.

## PREPARING THE HEAT SINKS

☐ **140.** The two heat sinks are shown in Fig. 17. Notice that they are not identical; they are mirror images. Put them on the table with the flanges up, in the positions shown. Be sure you match each to the drawing. Then mark them LEFT and RIGHT as indicated. Finally, mark the letters for the holes on the metal.

☐ **141.** You must now make 6-32 threads in the four holes in the longest flange of each heat sink, 8 holes in all. If you happen to have a 6-32 tap you can do this in the usual way. If not, do it as follows.

☐ **142.** Put a drop of any light lubricating oil in each of the holes.

☐ **143.** Put the head of a 6-32 hex-head self-tapping screw (Fig. 2-A) into a ¼-inch nutdriver. Put the tip of the screw in the hole. Holding the screw as perpendicular as possible to the metal, turn the screw slowly and apply pressure. The screw will bite into the metal and start to cut threads.

☐ **144.** You will need force to turn the screw. Whenever the needed force seems to get a bit greater, back the screw out a half turn to free the hole of metal chips, then go on.

☐ **145.** After a certain point (when perhaps ⅛ inch of the screw tip shows on the inside of the flange) turning will get much easier, indicating that the hole is fully threaded. Go on for a turn or two. Then back the screw out all the way.

☐ **146.** Do all eight holes this way, using a screw for only two holes, then throwing it away and using a new screw.

☐ **147.** When you have done all four holes in each heat sink, clean up all oil and metal chips. Test each hole by running one of the 6-32 screws from your kit into and out of it.

☐ **148.** Holes V, W, X, Y, Q, and R must now be threaded 4-40. If you have a 4-40 tap, use it in the usual way. If not, use the twelve 4-40 × ½ hex-head self-tapping screws in the kit to tap these holes in the same way you tapped the flange holes in steps 142 through 145. **NOTE WELL** the following differences between the job in steps 142 through 145 and the job you are doing now.

A. There are 6 holes per heat sink, 12 in all.

B. These holes are to be tapped 4-40, not 6-32, using (if you do not have a regular tap) the 4-40 × ½ hex-head self-tapping screws, identified with the aid of Fig. 2-A.

C. Use each screw for only *one* hole; then throw it away.

**SPECIAL NOTE**: Some 3/16 nutdrivers (which is what you need for these 4-40 screws) are so made that, while they will grip the hex head of the screw satisfactorily if the head is near the tip of the nutdriver socket, they will not do so if the screwhead is all the way inside the socket, as it must be when you apply pressure in tapping these holes. The inner size of the socket apparently is larger all the way inside the socket.

The solution is to put a nut into the driver's socket first, so the screwhead does not go far enough in to encounter this larger-diameter part. For this purpose, the kit contains one 2-56 nut, not shown in Fig. 2-A. Its center hole is too small to fit on any of the screws, so you will not use it mistakenly in assembly. Its over-all size is smaller than any other nut furnished.

If your 3/16 nutdriver does grip the heads of these 4-40 self-tapping screws at the driver tip but not with the head inserted all the way, put the 2-56 nut into the nutdriver first.

☐ **149.** Carefully clean up all the oil and metal chips. Then check the tapping of each hole by running a 4-40 machine screw in and out.

## ASSEMBLING THE LEFT HEAT SINK

☐ **150.** Gather together the *left* heat sink, two large transistor sockets (Fig. 2-B), 4 4-40 × 7/16 round-head machine screws, 4 No. 4 lockwashers, and 4 4-40 nuts.

☐ **151.** Put the left heat sink before you in the position of Fig. 18, flanges up. Put a transistor socket *under* the heat sink, under holes A-B-E-F-D-C, its flat face up against the underside of the metal, its terminals pointing down. Move and turn it until all six of the socket's holes are visible through the holes in the metal. There is only one position of the socket in which this is possible.

☐ **152.** Pass screws down through holes B and D and through the corresponding holes in the socket. Under the socket add lockwashers and nuts, running them up only finger tight.

☐ **153.** Move the socket around until all four of its remaining visible holes are well centered under holes A, F, E, and C. Then tighten the screws firmly.

☐ **154.** Mount the second socket in exactly the same way under holes G-H-M-J-L-K, the screws through holes H and L.

☐ **155.** Under the heat sink and socket put a solder lug on the screw through hole B, against the nut. Then add a second nut and tighten it while you hold the lug so its end points directly toward the other socket, as shown. (Notice the use in Fig. 18 of the standard convention which shows everything that is actually invisible in this particular view—under the metal in this case—in dashed lines.)

☐ **156.** Select one of the *larger* cable clamps. Compress it and put its holes over the screw through hole H, against the nut. Its flat face should be nearest the underside of the heat sink. Add a 4-40 nut. Then, holding the clamp so its loop points at the large rectangular cutout as shown, tighten the nut.

☐ **157.** Select a thermostat, three thermistors (note the difference between thermistors and thermostats in Fig. 2-B), a 2-terminal tie point, three thermistor clips, two 4-40 × 7/16 round-head machine screws, two No. 4 lockwashers, two 4-40 nuts, and your capsule of grease.

☐ **158.** Look at Fig. 19. Put the thermistor clips on the table as you see them in the drawing. Press a thermistor down into each clip, with its red dot located as shown. They are tight fits, but once you have inserted one you will have no trouble pressing it down as far as it will go, so that its flat end is flush with the lower end of the clip. Check carefully to see that each red dot is located as shown with respect to the position of the clip. Then mark each clip plainly where shown with its number 1, 2, or 3.

☐ **159.** Use your wirecutting pliers to clip off the curved part of the tie point mounting foot as shown by the dashed line in Fig. 20.

☐ **160.** Apply a film of grease to the flat metal face of the thermostat, the face opposite the terminals, which is down in the thermostat drawing in Fig. 2-B.

☐ **161.** Look again at Fig. 18 and notice the position of thermistor clip No. 1. Put your No. 1 in that position over hole P. Drop the end of a screw down through the hole in the clip and hole P. Hold the screw in place with a finger.

☐ **162.** Under the heat sink put the hole in one mounting ear of the thermostat's mounting bracket over the screw, the greased face of the thermostat up, nearest the underside of the heat sink. Add a lockwasher and a nut, turning the nut on only enough to keep it in place.

☐ **163.** Over hole N on the top face of the heat sink place

first thermistor clip No. 3, then No. 2, each clip turned as shown in Fig. 18. Drop a screw through both clip holes and through hole N.

☐ **164.** Put the remaining mounting ear of the thermostat up over the screw through hole N. Follow with the mounting foot of the tie point, the terminals facing away from the heat sink. Add a lockwasher and nut but do not tighten.

☐ **165.** Under the heat sink, turn the thermostat in its loose mounting ring so that its two terminals point as shown, one toward hole T, the other, of course, in the opposite direction. (In Fig. 2-B the thermostat terminals are also shown in the correct position with respect to the mounting ring ear holes.) Then tighten screw P, holding thermistor clip 1 so it is positioned just as shown.

☐ **166.** Hold the 2-terminal tie point under the thermistor and hole N so its insulating strip is at right angles to the nearby lower edge of the heat sink, and hold thermistor clips 2 and 3 as shown. Then tighten screw N. Check positions of thermostat, tie point, and thermistors (and see that their red dots are all in the direction of the large cutout at the right side of the heat sink). Make any slight necessary repositioning corrections by loosening and retightening screws.

☐ **167.** Clip off all six thermistor wires so only ¾ inch of each remains.

☐ **168.** Install a 4-terminal tie point over holes Q and R, on top of the heat sink, fastening it with 4-40 X ¼ pan-head machine screws. No nuts and lockwashers are necessary, as the holes are threaded.

☐ **169.** Look at Fig. 21. Placing a finger behind the insulating strip just at the location of the mounting foot at each end, bend the entire tie point over until the very tips of its terminals are exactly ⅜ inch from the metal face of the heat sink. Don't guess; measure.

☐ **170.** Notice in Fig. 18 that three of the tie point terminals are numbered. Write these numbers on the metal as shown. (The second terminal is, of course, No. 2—but hole T prevents your being able to write it.)

This completes assembly of the left heat sink. The screws and cable clamps in holes S-T-U will be put there later.

## ASSEMBLING THE RIGHT HEAT SINK

You assemble the right heat sink for a **2-channel amplifier only.** If yours is a 1-channel amplifier, no parts are fastened to the right heat sink. In that case, skip this entire section and go now to step 181.

This job is done in exactly the same way as assembly of the left heat sink; the positions of the parts are a mirror image of those in the left heat sink. Note, however, that a completely separate set of drawings is provided to avoid errors. Be sure you are referring to the correct drawings. The instructions will not be so detailed as those in steps 150 through 170, but you should do things the same way and take the same precautions. Refer to Fig. 22, not Fig. 18.

☐ **171.** Mount two large transistor sockets under hole groups A-B-E-F-D-C and G-H-M-J-L-K with 4-40 X 7/16 round-head machine screws through holes B, D, H, and L, plus lockwashers and nuts.

☐ **172.** Add a solder lug under hole L and a large cable clamp under hole D. Hold both in place with added nuts, turning each in the direction shown when you tighten.

☐ **173.** Put thermistors into clips as shown in Fig. 23. Be sure you get the clips in the positions shown, and notice that this time the red dots on the thermistors are toward the left. Number each clip plainly.

☐ **174.** Clip off the curved part of the mounting foot of a 2-terminal tie point per Fig. 20.

☐ **175.** Grease the flat face of your remaining thermostat.

☐ **176.** Put thermistor No. 1 in the position shown in Fig. 22 and drop a 4-40 X 7/16 round-head machine screw down through the hole in the clip. Under the heat sink put one hole in the thermostat mounting ring over the screw, greased face of the thermostat toward the metal. Add a lockwasher and nut very loosely.

☐ **177.** Put clips 3 and 2 in position. Drop a similar screw down through their holes and hole P and the remaining hole in the thermostat mounting ring. Under the thermostat add the clipped mounting foot of the tie point, then a lockwasher and nut.

☐ **178.** Turn the thermostat in its mounting ring so the terminals are positioned as shown. Tighten screw N, holding thermistor 1 as shown. Then tighten screw P, holding thermistors 2 and 3 and the tie point in position. Check and readjust as necessary.

☐ **179.** Cut down each thermistor wire to ¾ inch.

☐ **180.** Mount a 4-terminal tie point over holes Q and R with 4-40 X ¼ pan-head machine screws. Bend the tie point over as in Fig. 21. Number the terminals as shown.

## WIRING THE LEFT HEAT SINK

☐ **181.** Put the LEFT heat sink on the table in the position of Fig. 18. Get the right sink out of the way so you don't accidentally work on it at this point.

☐ **182.** Put Fig. 24 before you. Check the thermistors again to see that the red dots are toward your right. Connect *but do not solder* the thermistor wires to the terminals as shown. Do not pull the wires tight. See that no wire can touch any other wire, any terminal to which it is not connected, or the metal of the heat sink or its clip, or the body of the thermistor itself.

☐ **183.** Prepare 6¾ inches of brown wire, 7½ inches of purple, and 8½ inches of orange—but strip one end only ⅛ instead of the usual ¼ inch, on each piece.

☐ **184.** Connect the ¼-inch ends of the wires to the tie point terminals as follows, in each case draping the body of the wire over the insulating strip of the tie point and making the connection to one side of the large terminal hole rather than to the tip. As you make each connection, solder it and also the thermistor wire or wires also connected to that terminal.

**Brown** wire to terminal 1.
**Purple** wire to terminal 3.
**Orange** wire to terminal 4.
Solder the thermistor wires to terminal 2.

☐ **185.** Press all three wires down against the metal of the heat sink and keep them there temporarily with a bit of tape.

☐ **186.** Prepare the following wires:
4½ inches of yellow.
5½ inches of *thin* black.
8 inches of *thin* black.

☐ **187.** Prepare the following wires, but strip one end of each only ⅛ inch instead of the usual ¼ inch. **NOTE:** When you connect these wires to heat-sink points, connect only the ¼-inch ends. Leave the ⅛-inch ends free.
11½ inches of green.
7½ inches of *thin* white.
7½ inches of blue.

7½ inches of orange.

☑ **188.** Turn the heat sink over and put it before you as it appears in Fig. 25. In following the instruction steps, route the wires and position the resistors as shown in Fig. 25.

☑ **189.** If you wish, you can mark on the metal and/or the transistor sockets, etc., the terminal identifications shown in Fig. 25 for the connection points of the transistor sockets, the thermostat, and the 2-terminal tie point. Whether or not you mark them at this point, be absolutely sure you get them right when you make the connections.

**NOTE:** When you install the rectangular power resistors, see that the marking on each one faces up so you will be able to read it now and later.

☑ **190.** Bend the wires of a .1-ohm, 3-watt resistor to right angles with its body and insert them through the *lower* holes (the holes which also go through the insulating strip) of L1 and L2. Push the wires far enough into the holes so the resistor is positioned as shown. Solder both wires and clip off the excess to the left of the tie point.

**NOTE:** As usual, solder each connection as you make it unless specifically told not to.

☑ **191.** Connect one end of the 4½-inch yellow wire to 1C. Connect *but do not solder* the other end to the upper part of L2.

☑ **192.** Connect the 11½-inch green wire to 1B. Route it as shown and up through the cable clamp.

☑ **193.** Connect both the 5½-inch and 8-inch thin black wires to solder lug G1.

☑ **194.** Connect the blue wire to 2B and route it as shown and up through the clamp.

☑ **195.** Connect *but do not solder* the white wire to L2 and lead it up through the cable clamp.

☑ **196.** Connect *but do not solder* the orange wire to 2C. Route it as shown and up through the cable clamp.

☑ **197.** Cut one wire of a .2-ohm, 5-watt resistor down to ¾ inch. Connect that end to 1E.

☑ **198.** Cut one wire of a second .2-ohm resistor down to ¾ inch. Connect the cut end to 2C. When you solder it, solder also the orange wire already on 2C.

☑ **199.** Cut one wire of a third .2-ohm resistor down to ¾ inch, the other to 1 inch. Connect the short wire to L2 and the long one to 2E. When you solder to L2, solder also the white and yellow wires already there.

☑ **200.** Check to see that all connections are soldered and that all wires and resistors are positioned as shown in Fig. 25, with no bare wire touching anything to which it is not connected.

## WIRING THE RIGHT HEAT SINK

If yours is a **1-channel amplifier**, omit this section and go now to step 218.

This is a repetition of your work in steps 181 through 200, adjusted for the mirror-image orientation of the right heat sink. Do it just as you did the left heat sink.

☑ **201.** Put the right heat sink on the table in the position of Fig. 22. Check the thermistors to see that all the red dots are toward your left. Then connect the thermistor wires to the tie-point terminals as shown in Fig. 26.

☑ **202.** Prepare 7 inches of orange wire, 8 inches of brown, and 7½ inches of purple—but strip one end of each only ⅛ inch instead of the usual ¼ inch. Connect the ¼-inch ends.

☑ **203.** Leading the wires to the terminals over the insulating strip of the tie point, connect the orange wire to terminal 4, the purple to 3, and the brown to 1. Solder the thermistor wires to terminal 2, as well as all other connections.

☑ **204.** Press all three wires against the metal and tape them there.

☑ **205.** Prepare the following wires. Prepare the yellow in the usual way, but on the remaining four, strip one end only ⅛ inch instead of the usual ¼ inch. Connect only the ¼-inch ends.

4½ inches of yellow.
11½ inches of green.
7½ inches of *thin* white.
7½ inches of blue.
7½ inches of orange.

☑ **206.** Turn the heat sink over and put it before you as in Fig. 27. Route wires and position resistors as shown.

☑ **207.** Mark the terminal identifications on the metal if you wish.

☑ **208.** Install a .1-ohm, 3-watt resistor in the lower holes of L1 and L2.

☑ **209.** Connect one end of the yellow wire to 1C. Connect *but do not solder* the other end to the upper part of L2.

☑ **210.** Connect the green wire to 1B.

☑ **211.** Connect the blue wire to 2B.

☑ **212.** Connect *but do not solder* the white wire to L2.

☑ **213.** Connect *but do not solder* the orange wire to 2C.

☑ **214.** Cut one wire of a .2-ohm resistor to ¾ inch and connect that end to 1E.

☑ **215.** Cut one wire of a .2-ohm resistor to ¾ inch and connect it to 2C, soldering also the orange wire.

☑ **216.** Cut one wire of a .2-ohm resistor to ¾ inch, the other to 1 inch. Connect the short wire to L2, the longer one to 2E. When you solder at L2, solder also the white and yellow wires.

☑ **217.** Check everything carefully.

## FINAL MECHANICAL ASSEMBLY

☑ **218.** Collect the following items, with the aid of Fig. 2-A: 12 No. 10 X ⅜ (larger of the two sizes furnished) shoulder washers, the remaining plastic cable clamps, 6 10-32 X ⅝ pan-head machine screws, 6 No. 10 lockwashers, and 6 10-32 nuts. You will also need an ordinary wooden pencil, the LEFT heat sink, and the transformer chassis.

☑ **219.** Put the transformer chassis on the table as in Fig. 28.

☑ **220.** Lay a shoulder washer on the upper flange, right over each of its three holes, with the shoulder facing *up*, as indicated by W1 in the drawing.

☑ **221.** Lay the pencil on the transformer as shown.

☑ **222.** Make sure the wiring on the heat sink is close to the transistor sockets and clear of holes U, T, and S. Bend the connected wire of the resistor attached to 1E so that wire, the resistor body, and the free wire point straight away from the metal face of the heat sink.

☑ **223.** Bend the two black wires connected to G1 so those wires, too, run straight away from the heat sink.

☑ **224.** Hold the heat sink horizontal, its flanges facing up, turned so the large rectangular cutout is closest to you. Lower it carefully so the up-facing shoulders of the three washers sitting on the transformer chassis flange enter holes U, T, and S. Rest the heat sink on the shoulder washers and the pencil. Then do whatever is necessary to see that the shoulder of each washer is actually inside a heat sink hole and that holes U, T, and S are directly over the transformer

chassis flange holes.

☐ 225. Insert three more shoulder washers down into holes U, T, and S, their shoulders snugly inside the holes. These washers are represented by W2 in Fig. 28. The point of this operation is to fasten the heat sink to the transformer chassis without allowing the two pieces of metal to come into contact and without letting the fastenings touch the metal of the heat sink.

☐ 226. Pass a screw down through each set of holes and shoulder washers. Under the flange of the transformer chassis put a lockwasher and nut *only on the screw through hole U.* Run the nut right up to the underside of the flange but tighten it with your fingers only.

☐ 227. Without moving the assembly, remove the screw from hole S. Pass it through both holes in one of the *smaller* cable clamps, the flat side of the clamp farthest from the screwhead. Then replace it in hole S. Under the transformer chassis flange add a lockwasher and nut, finger tight. Rotate the cable clamp so its loop faces as shown in Fig. 18.

☐ 228. Tip the assembly to your right so it rests on the transformer corner and the unflanged edge of the heat sink. Remove the screw from hole T, along with the shoulder washer just under the screwhead (because the washer would fall out, if you didn't remove it, and get lost on the floor at the one location where you would never find it).

☐ 229. Take the washer off the screw. Pass the screw through both holes in a *small* cable clamp, the flat side of the clamp farthest from the screwhead. Put the shoulder washer back on the screw. Pass the screw back into hole T.

☐ 230. Where the screw emerges under the transformer chassis flange, put a *large* cable clamp over it, after first opening the clamp and putting through its loop the green and yellow wires which run past the thermostat. Add a lockwasher and nut, finger tight. Turn the clamp under the screwhead so its loop faces as in Fig. 18 and the large one under the chassis flange so it squarely faces the thermostat. Then tighten the screw very firmly.

☐ 231. Now tighten the other two screws, seeing that the cable clamp held by screw S continues to face the right way (Fig. 18). See that the shoulders of all six washers are right inside their holes. Check the green and yellow wires to see that they run freely through their clamp and are not pinched in the part of the clamp having the screw holes.

☐ 232. Tip the assembly back up into the position of Fig. 28. Untape the three wires connected to the 4-terminal tie point from the metal. Pass them first through clamp T, then through clamp S and pull all slack through. Then retape them to the metal to keep them out of the way.

☐ 233. With the pencil still in place to keep the weight of the transformer from straining the chassis flange and screw fastenings, carefully turn the assembly over so it rests on the flanges of the left heat sink, turned so the large cutout in the heat sink is toward your left.

☐ 234. Put a shoulder washer over each of the three holes in the transformer chassis flange which is uppermost, with the shoulders *up.* Put a second pencil atop the transformer, its position corresponding to the first.

☐ 235. Hold the RIGHT heat sink, flanges up, and the large cutout to your left. Lower it onto the chassis flange so the shoulder washers go into holes U, T, and S.

☐ 236. Place a shoulder washer over each of the three holes in the heat sink, being sure the shoulders go into the holes.

☐ 237. **1-channel only.** Drop screws down through each of the three sets of holes and shoulder washers. Under the chassis flange add lockwashers and nuts. After seeing that all six washer shoulders are inside their holes, tighten the three screws firmly.

**NOTE:** The following steps are for **2-channel only.** If yours is a 1-channel amplifier go now to step 245.

☐ 238. Drop screws down through each of the 3 sets of holes and shoulder washers. Add a lockwasher and nut underneath *to screw S only.* Run the nut up finger tight.

☐ 239. Remove the screw from hole U. Pass it through the holes in a *small* cable clamp, the flat side of the clamp farthest from the screwhead. Reinsert the screw in hole U. Underneath add a lockwasher and nut, finger tight. Turn the clamp so it faces as shown in Fig. 22.

☐ 240. Rotate the assembly so it rests on the unflanged edges of both heat sinks, the transformer hanging down. You can remove both pencils.

☐ 241. Remove the screw from hole T and catch the shoulder washer right under the screwhead; it must be removed from the screw in any case. Put a *small* cable clamp under the screwhead, flat side farthest from the screwhead. Add the shoulder washer and reinsert the screw in hole T, with the shoulder of the washer inside the hole.

☐ 242. Under the chassis flange add a *large* cable clamp, after first opening up the clamp and passing its loop around the yellow and green wires running past the thermostat. Add a lockwasher and nut. Turn the small clamp so it faces as shown in Fig. 22 and the large one so its loop is squarely toward the thermostat. See that the green and yellow wires run freely through the loop of the large clamp. Then tighten the screw very firmly.

☐ 243. Now tighten the other two screws firmly. Check to see that all shoulder washers are in their holes and all cable clamps positioned as specified.

☐ 244. Untape the three wires connected to the tie point from the chassis and pass them through clamps T and U in that order. Then retape the free wires to the chassis to keep them out of the way.

☐ 245. See that all six screws holding the two heat sinks to the transformer chassis are good and tight. The transformer is heavy and you want no chance of their ever working loose.

☐ 246. Stand the assembly on the table resting on one flange of each heat sink, the large cutouts in both sinks down and the unflanged edges of both sinks toward you. The left heat sink is at your left, the right to your right. Fig. 29 shows the outer face of the left heat sink. To anyone viewing Fig. 29 directly, your head would be toward his right.

☐ 247. The uppermost flanges of both sinks have three slots each. Put a *small* shoulder washer over each slot, shoulder down and inside the slot.

☐ 248. Hold the rear panel horizontal, its black face up, the rectifier farthest from you. Set it atop the assembly so the three holes in each edge are approximately over the heat sink slots, the panel resting on the six shoulder washers.

☐ 249. Align the rear panel so its three left holes are right over the shoulder washers and slots of the left heat sink. Drop a 6-32 X ½ *black* pan-head machine screw down through each of the three left holes, through the shoulder washers and the heat sink slots. Under the heat sink flange add to each screw a shoulder washer, shoulder up, a No. 6 lockwasher, and a 6-32 nut. Making sure the latest shoulder washer

shoulders are actually inside the slots, tighten all three nuts enough to hold things together but not enough to prevent the possibility of sliding the panel around a bit.

☑ **250.** Now do exactly the same with the right set of panel holes and the slots of the right heat sink. Remember to use three more shoulder washers under the heat sink flange. Slide the panel enough to be able to get the screws through. Again tighten only enough to permit some movement.

☑ **251.** Look into the opening between the panel and the heat sink flange on each side to be certain all washer shoulders are in their slots or holes.

☑ **252.** At the left edge only, slide the panel as necessary to make the edge of the heat sink flange and the edge of the rear panel parallel. Do not try to make them even—only parallel. Then tighten all three screws very firmly.

☑ **253.** Now do exactly the same on the right side, pulling the two heat sinks apart slightly or pressing them together as necessary to make the two items parallel. Tighten the three screws to keep them so. Make sure all six screws are now good and tight.

☑ **254.** Pad the table with newspaper. Then turn the assembly over so it rests on the rear panel, the unflanged edges of the heat sink again facing you.

☑ **255.** Insert shoulder washers in the heat sink slots, the shoulders down in the six slots.

☑ **256.** Rest the front panel on the washers, the six edge holes approximately over the shoulder washers. The lettering face should be up, the lettering reading upside down, the edge with the volume control(s) closest to you. See that all wiring is between the heat sinks, none pinched between the panel and the heat sink flanges.

☑ **257.** Fasten the front panel to the heat sinks just as you did the rear panel, this time using the metal-colored 6-32 × ½ pan-head machine screws. Below each heat sink flange add shoulder washers, shoulders up and inside the slots, plus lockwashers and nuts. Align one side first, then the other. See that the screws are tight.

## FINAL WIRING

☑ **258.** Put the assembly on the table with the transformer hanging down and the rear panel nearest you. Don't let any wires get trapped against the table; tuck them all inside.

☑ **259.** Examine Fig. 30. It shows the inside of the unit as you stand looking down into it. The heat sinks and front and rear panels have been flattened out so you can see what is on them better. Only what you need to see for this final wiring job is shown, so much of what you see in your actual unit is simply omitted in the drawing. Gaze at Fig. 30 until you are sure you understand exactly how it relates to your assembly and you can see exactly what part and terminal each item in the drawing refers to in the 3-dimensional conglomeration of parts that stands before you on the table.

**NOTE**: As before, prepare wires by stripping ¼ inch of insulation from each end unless otherwise instructed, and solder every connection as soon as it is made—again, unless you are told to do otherwise.

It is especially important here to take care with connections. You are working in smaller space than before, with lots of other wires and paraphernalia about to get in your way. See that you have enough light to see every connection absolutely clearly to check that it is made to the right point, that it has been soldered perfectly, and that nothing made of metal, including wire, is touching anything it shouldn't. While everything in the amplifier is accessible for repairs, think how much better it will be to double check everything you do than to be slapdash and have to go rooting around later to find what you did wrong!

☑ **260.** Connect the two red transformer wires coming from hole A on the transformer chassis to the left and right terminals of the rectifier on the rear panel. Push the wires down against the metal, out of the way.

☑ **261.** Connect the *shorter* of the two black wires coming from solder lug G1 on the left heat sink to solder lug G on the rear panel. Push the wire down against the metal.

☐ **262. 1-channel only.** Pass a 4-40 × ¼ pan-head machine screw through hole L in the *right* heat sink, from the outside. On the inside surface put a solder lug on the screw, followed with a nut. Tighten the screw, with the end of the solder lug pointing toward the front panel, as you see lug G1 on the right heat sink in Fig. 30.

☑ **263.** Connect the remaining black wire from G1 on the left heat sink to G1 on the right heat sink, but *do not solder.*

☑ **264.** Lead the free end of the thin black wire soldered to the bare jumper wire between the two large capacitors on the transformer chassis past single tie point J and over to lug G1 on the right heat sink and connect it to the hole in G1. Solder both it and the wire installed in step 263. Press both black wires down to the metal but don't let them cover any wire which still has a free end.

☑ **265.** Connect, *but do not solder,* the *heavier* yellow wire from the undotted terminal of capacitor G to the lowest terminal of the rectifier on the rear panel.

☑ **266.** Connect the free wire of the .2-ohm resistor from terminal 1E on the left heat sink to the lowest rectifier terminal, *but do not solder.*

☐ **267. 2-channel only.** Connect the free wire of the .2-ohm resistor from 1E on the right heat sink to the lowest rectifier terminal.

☑ **268.** Now solder the yellow wire and either one (1-channel) or two (2-channel) resistor wire(s) to the lowest rectifier terminal. Press the yellow wire against the transformer chassis. The resistor(s) should be out in midair.

☑ **269.** Lead the heavy red wire from the red-dotted terminal of capacitor F to the uppermost (red-dotted) terminal of the rectifier, along the surface of the metal, and connect it there.

☑ **270.** Looking at your front panel, notice that near the table surface there is a bare wire running about parallel with the table through twisted solder lug(s) under the phono jack(s). (The reason for the parenthesized s's is that you have either one or two such jacks and twisted lugs, depending on how many channels in your amplifier.) Soldered to this bare wire is a heavy black one. Lead it up the surface of the front panel between circuit breaker and power switch, as shown, across the gap to the transformer chassis, and solder it to the bare jumper wire between capacitors F and G.

☑ **271.** Connect the free end of the heavy black wire from the solder lug attached to the black Channel A binding post to the same bare jumper wire between capacitors F and G.

☑ **272.** Locate the free ends of the twisted pair of black wires from the transformer which runs through cable clamp K. Connect and solder one wire to the upper terminal of the power switch. Connect *but do not solder* the other one to the lowest terminal. Let the excess length droop into the space between transformer and front panel.

☑ **273.** One wire of your a.c. line cord is shorter than the

other because you cut a piece away. Separate the two wires additionally as necessary and cut a 7-inch piece from the longer one. Strip the cut piece ¼ inch at each end but *twist and tin the strands at one end only;* do not put any solder on the other end.

☑ 274. Solder the tinned end to thermostat terminal T2 on the left heat sink. If you find this terminal does not easily take solder, turn the assembly temporarily onto the left heat sink so the terminal is horizontal and apply enough heat so you can see the solder flow over the terminal. Then right the assembly again.

☑ 275. Pass the free end of the wire from T2 through the cable clamp just below the thermostat, in the direction of the front panel. Insert the end in a hole in the left heat sink flange to keep it out of the way.

☑ 276. Pull the line cord apart as necessary and cut a 10-inch piece from the longer wire. Strip and tin both ends. Solder one end to T1 on the left heat sink. Lead the free end through the clamp below the thermostat toward the front panel, through clamp K. Solder it to the upper terminal of the circuit breaker. If the wire is too heavy to hook into the terminal hole, clinch it *around* the terminal before soldering.

☑ 277. Now see that the line cord wires are separated for a distance of about 7 inches from the end of the longest one. The shorter should be 4 inches shorter than the longer; trim as necessary. Strip each wire ¼ inch, but tin only the longer one; do not put any solder on the shorter wire.

☑ 278. Pass both line cord wires into the assembly through the rubber grommet in the rear panel. Inside the assembly tie a knot in the cord placed so that when the cord is pulled back out until it is stopped by the knot, the longer wire extends a full 11 inches from the inner surface of the rear panel. You may have to tie and untie the knot a couple of times until you get this right. When you finish, pull the line cord out until the knot is against the grommet.

☑ 279. Pass the longer line cord wire through cable clamp K toward the front panel. Since the clamp is already fairly well filled, you will probably have to remove the nut, solder lug, and washer at K and open the clamp to get the wire in. Replace these items and tighten the nut.

☑ 280. Connect the end of this longer line cord wire to the lower terminal of the power switch. Solder it, along with the black wire already there.

**NOTE:** The connections in the following steps marked **1-channel only** are not shown in Fig. 30.

☐ 281. **1-channel only.** Find the ends of the two unconnected line cord wires—one coming through the rear panel grommet from the line cord itself, and the other from T2 on the left heat sink. Strip a little more insulation from each so that about ⅜ inch of bare wire shows. *Do not apply any solder.*

☐ 282. **1-channel only.** Connect these two wire ends together by holding the two parallel while twisting the bare strands of both together in a *clockwise* motion. Continue to hold both wires by the insulation close to the bared ends. Put the open end of a wire nut (Fig. 2-A) over the points of the spliced wires and wind it on as tight as you can, turning it clockwise. Hold the nut and tug on the wires to be sure they are secure. Then push nut and wires down against the chassis.

☑ 283. Connect *but do not solder* the free wire of the .2-ohm resistor from 2C on the left heat sink to the top part of tie point J.

☑ 284. **2-channel only.** Connect the free wire of the .2-ohm resistor from 2C on the right heat sink to the top part of tie point J. Solder it and all the other wires at J.

☐ 285. **1-channel only.** Solder all connections on tie point J. Then double the free end of the longer red wire from J right back to J. Hold it against the solder on J and heat, to hold it on J. The purpose is merely to hold this free end of wire in place on J. You will not use it now, but if you later convert this to a 2-channel amplifier you will use it then.

☐ 286. **1-channel only.** In the same way, without making a mechanical connection, solder the free end of one of the two yellow wires from the undotted terminal of capacitor G to the same terminal from which it comes. Again, you are just "storing" this wire in case you later convert to 2-channel. Push the two stored wires down to the metal.

☑ 287. **2-channel only.** Tin the bared end of the line-cord wire from T2 on the left heat sink. Pass it through the clamp below the thermostat on the *right* heat sink in the direction of the rear panel and solder it to T2 on the right heat sink. (For this and the next soldered connection you may find it useful to turn the assembly temporarily over onto the right heat sink so the thermostat terminals are horizontal.)

☑ 288. **2-channel only.** Pass the remaining wire from the a.c. line cord through the same clamp as in step 287, in the same direction, and solder it to T1 on the right heat sink.

☑ 289. Pass one yellow wire from the undotted terminal of capacitor G and the shorter red wire from tie point J up through the cable clamp attached to a transistor socket on the left heat sink.

☑ 290. **2-channel only.** Pass the other yellow wire from the undotted terminal of G and the longer red wire from J up through the clamp attached to a transistor socket on the right heat sink.

## PRINTED CIRCUIT INSTALLATION

☑ 291. Rest the amplifier on the right heat sink so the left heat sink is up, with the front panel to your right. Lead the six wires from the clamp on the back of the left heat sink up through the large cutout.

☑ 292. Put one printed circuit board, *painted side up,* on the heat sink just left of the large cutout, turned so the row of tubular terminals is nearest you.

**NOTE:** To connect a wire to a tubular terminal, melt a bit of solder on the iron. Hold the tip of the wire pointing down into the open end of the terminal and resting on the solder which fills the terminal. Then put the iron against the side of the terminal. The wire end will sink into the molten solder in the terminal. Hold the wire in place, not letting it move, and take away the iron. When the solder has hardened let go.

☑ 293. In this step solder the six wires from the cable clamp to tubular terminals on the board.

**Red** to B+.
**Orange** to PC.
**Blue** to PB.
**White** to OT.
**Green** to NB.
**Yellow** to B+.

☑ 294. Bring the two gray wires from the Channel A SENSITIVITY control up through the cutout. Solder the one from the terminal nearest the circuit breaker (terminal 9 in Fig. 9) to F2 and the other to F1.

☑ 295. Bring the black wire from the bare wire attached to the grounding lug(s) of the phono jack(s) up through the

opening and solder it into terminal GND.

☐ **296.** Bring up the purple wire from the center terminal of the Channel A VOLUME control and solder it to terminal IN.

☑ **297.** Fold the board over so the copper side is up and put it right over the large cutout, with its M holes over holes V-W-X-Y, which you previously threaded. Fasten it down with four 4-40 X ¼ pan-head machine screws into those holes.

☑ **298.** Connect a 470-ohm (yellow-purple-brown), ½-watt resistor between tubular terminals D1 and D3. Lay the resistor on the copper surface of the board and wrap each wire once around a terminal. Solder and clip off excess.

Then bring over the three wires from the 4-terminal tie point to which the thermistors are connected. Solder them into tubular terminals in the usual way.

**Orange** into D3.
**Purple** into D2.
**Brown** into D1.

☑ **299.** Turn the amplifier as necessary so you can see inside and make sure no wires are trapped between circuit board and metal. Press the purple and black wires going to the circuit board against the metal along their paths, as well as the gray wires. Examine the board to see that all transistors are firmly in their sockets.

☑ **300.** Now rest the amplifier on the right heat sink again, left heat sink up, front panel to your right.

☑ **301.** Carefully clean the heat sink metal on the outside, over the two transistor sockets which are on the inside. There must remain no dirt, dust, or particles of any kind.

☑ **302.** Wash your hands.

☐ **303.** Open one envelope containing two transistor insulators—flat, diamond-shaped pieces. These insulators are fragile and must not be bent or broken. Wipe them off gently but thoroughly to remove any dirt or particles.

☑ **304.** Smear a film of grease from your capsule on *each face* of one insulator. Be extremely careful not to allow any foreign (or domestic) particles of anything to get on the insulator.

☑ **305.** Place the insulator down on the heat sink over the transistor socket holes. There is only one position in which the insulator holes will match the socket and metal holes. Center it nicely over the holes. Because of the grease it should adhere to the metal.

☑ **306.** Pick up a 40411 power transistor (Fig. 2-B) and put the tips of its two pins down just barely into the two small insulator holes and socket holes. See whether, if you pressed it all the way down, its large end holes would match those of the metal and socket. If not, turn it around. Then press its pins firmly down into the socket so the bottom of the transistor is down against the insulator.

☑ **307.** Fasten the transistor down with two No. 6 X ½ round-head self-tapping screws (Fig. 2-A). Tighten them firmly.

☑ **308.** In exactly the same way, grease the second insulator, put it in place, and install a second 40411 transistor in the remaining transistor socket with two more No. 6 X ½ round-head self-tapping screws.

☑ **309.** Now make a coil using the heavy white wire and one of the short, fat wooden dowels. Be guided by Fig. 31, and the following steps.

☑ **310.** Straighten one length of the heavy white wire. To do this, strip about 1 inch of insulation from each end. Clamp one end firmly in a vise. Grasp the other end with gas pliers and pull steadily on it until you can feel the wire stretch slightly. Then clip off the mutilated ends and do not let the wire get kinked again.

☑ **311.** Strip ¼ inch of insulation from one end of the wire. Pass that end through one hole in the dowel and allow 2 inches of wire to project on the other side of the hole. Bend over the projecting piece so it will not come back through the hole.

☑ **312.** Clamp the far end of the wire in a vise. Back off until you are far enough from the vise so the wire is taut. Now walk toward the vise, keeping the wire taut and rotating the dowel (makes no difference in which direction) so as to wind the wire in a coil around the dowel. Keep the coil tight and keep each turn pressed against the previous one so there are no spaces between turns.

☑ **313.** When you have wound so much wire on the dowel that one more turn would cover the empty hole, stop. Hold the wire firmly in place on the dowel and release the end from the vise. Pass that end through the dowel hole and pull it through all the way. The wound wire should now be incapable of moving.

☑ **314.** Clip off the new wire end so 2 inches remains. Strip the end of ½ inch of insulation. Your coil should now look like that of Fig. 31. Bend both ends so the wires point directly away from the dowel ends.

☑ **315.** Bend the ½-inch-stripped end into a hook and, with the amplifier on the table upside down, hook it into the end hole in the solder lug attached to the *red* Channel A binding post. Clinch the hook shut and solder.

☑ **316.** Connect and solder the other wire to L1 on the left heat sink (Fig. 30). Position the coil so it is suspended in space by its wires and touches nothing. If any other wires touch it, press them down to the metal.

**NOTE:** The following steps 317 through 328 are for **2-channel only.** If yours is a 1-channel amplifier, go now to step 329.

☑ **317.** Pass the red wire from tie point J and the yellow wire from the undotted terminal of capacitor G by the most direct routes up through the cable clamp attached to a transistor socket on the right heat sink. Now pass all six wires from that clamp out throughbthe large rectangular cutout.

☑ **318.** Rest the amplifier on the left heat sink, the right heat sink up and the front panel to your left.

☑ **319.** Put the remaining printed circuit board on the right heat sink, painted side up, the row of tubular terminals nearest you.

☑ **320.** Solder the six wires coming through the cutout to tubular terminals as follows.

**Yellow** to B—.
**Green** to NB.
**White** to OT.
**Blue to PB.**
**Orange** to PC.
**Red** to B+.

☑ **321.** Bring up the gray wires from the terminals of the Channel B SENSITIVITY control. Solder the one from the terminal nearest the on-off switch (J10 in Fig. 9) to F1 and the other to F2.

☑ **322.** Solder the purple wire from the Channel B VOLUME control to IN and the black wire from the bare wire between the two grounding lugs of the phono jacks to GND.

☑ **323.** Turn the board over, copper side up. Place it over the cutout and fasten it down with four 4-40 X ¼ pan-head

machine screws into threaded holes V-W-X-Y.

☐ 324. Connect a 470-ohm (yellow-purple-brown), ½-watt resistor between tubular terminals D1 and D3. Lay the resistor body on the copper surface of the printed board and wrap each wire once around each terminal; solder and clip off excess.

Then connect the three wires from the tie point to which the thermistors are wired, inside terminals as usual:

**Brown** to D1.
**Purple** to D2.
**Orange** to D3.

☐ 325. Turn the amplifier as necessary and check for loose transistors, trapped wires, etc. Press the gray, purple, and black wires against the metal.

☐ 326. Put the amplifier on its left heat sink again, right heat sink up.

☐ 327. Install two 40411 transistors in the two sockets by following steps 301 through 308. Please don't do this from memory. Do it step by step, following the text.

☐ 328. Make a second coil by following steps 309 through 316—*except that* in steps 315 and 316 the coil is to be connected to the solder lug on the red *Channel B* binding post and L1 on the *right* heat sink.

**NOTE**: Now the instructions begin again to apply to both 1-channel and 2-channel amplifiers.

☐ 329. Rotate the volume control shaft(s) fully counterclockwise. Loosen the setscrew in a knob so the knob will slip onto the shaft all the way. Turn the knob so the pointer points at the letter V in VOLUME. Tighten the screw. Install the other knob on the other volume control for a 2-channel amplifier in the same way.

☐ 330. Cut four 1¼-inch lengths from your piece of felt. Turn the amplifier onto its rear panel, front panel up. Insert a piece of felt into the space between front panel and each heat sink flange just about at the location of the volume and sensitivity controls. In each side, insert the longer edge of a piece, with about half of it sticking out. You will probably have to loosen the screws holding the front panel to the heat sink flanges to get the pieces in. Do this one side at a time and tighten the screws again before going to the other side. Fig. 32 shows what the felt "ears" look like when you are through.

☐ 331. Turn the amplifier on its face and insert two more felt pieces between the rear panel and heat sinks in the same positions. Again, the job will look like Fig. 32.

## TESTING THE AMPLIFIER

Your amplifier is now complete except for putting on the outer case. This is the time to spend quite a lot of time examining it in minute detail. Use a good light (a flashlight works well for some of the inner parts) and a very critical eye and touch. Remember that this is a *power* amplifier, in which an error of any kind is capable of causing instant destruction of certain parts.

Begin by pressing the red circuit breaker button all the way in and then releasing it. This assures that the breaker is on to begin with.

See that every connection appears to be securely soldered. See that no bare wire is touching anything but what it is connected to. This applies especially to the rectangular resistors. See that all the connections seem to make some subtle kind of sense, even if you don't know anything about electronics. If anything seems a trifle odd, even on a purely psychic basis, check it against the instructions.

Read through the instructions again to see whether you get the feeling that your hands failed to do something your eyes read, or that they did something different. If you get that feeling, check the amplifier.

You should quite rightly be a little reluctant to turn the amplifier on and face the moment of truth—so that when you finally do so, you will feel that there is not another thing you could possibly have checked, and that if there is anything wrong it could not conccivably be your fault.

Now turn the amplifier rightside up on a clean table—no stray bits of wire, please; no tools knocking around loose.

Stay away from the heat sinks and the exposed wiring on them and the exposed copper sides of the circuit boards. With the cover off, those places are vulnerable. You could touch them with your metal watchband, short a couple of connections, and see sudden smoke.

Before turning the amplifier on there is one electrical test you can make if you have an ohmmeter. Check resistance between the case of each power transistor and the heat sink to which it is attached. The resistance should be not less than 50 ohms. This assures you that the transistor insulator has not been punctured.

Make the very elemental first test as follows.

☐ 332. Turn both volume controls and sensitivity controls (or one of each for a 1-channel amplifier) fully counterclockwise (off). Don't connect anything to the amplifier. Press in the lower part of the power switch to turn it off.

☐ 333. Connect the plug of the line cord to an outlet furnishing between 100 and 125 volts a.c., 50 or 60 Hz. Press the upper part of the power switch in to turn the amplifier on. The power switch should light up and the light should stay on. If it doesn't light up, or if it does and you then hear a click and the light goes off, you have trouble; go to the SERVICING section.

If you have at least one speaker system or a speaker of any kind, connect it to the binding posts of Channel A, turning the amplifier off before doing so. (It is always a good idea to have the amplifier turned off while you are making, removing, or changing any connections.) If you have two speakers connect one to each pair of binding posts. (A pair consists of one red post and the black one just below it.) See that both volume and sensitivity controls are fully off.

Now stick a small screwdriver into and through one of the phono jacks at the top of the front panel, the one on the same side to which the speaker is connected, or either one if two speakers are connected. Turn the amplifier on. Hold your finger on the metal of the screwdriver. Slowly advance the volume control on that side. You should hear a hum or buzz. Don't make it loud; just see that it is there. If your amplifier is 2-channel do the same on the other side, switching speaker connections if you have only one speaker.

The hum indicates the amplifier is alive and breathing—assuming you hear only silence when the screwdriver is not inserted in the input jack.

Finally, if you have some sound source with fairly high output such as a tuner or test generator, you can go ahead and actually listen to sound.

If everything appears to be kosher with these simple tests you can assume everything is fine. Subtle problems are unlikely.

If you are a technician or engineer and wish to put the amplifier through its paces on the test bench under maximum

rated conditions, please don't do it now. Read the next section on installation and operation, which has a few notes on bench testing (page 26, second column).

## INSTALLING THE CASE

When you are satisfied the amplifier is satisfactory, even if your only test was to turn it on and see that it stayed on (which probably is really a sufficiently definitive test), put on the outer case as follows.

☐ 334. Look once again to see that the amplifier is clean and devoid of extraneous junk inside and outside. Pass a straightedge over each heat sink, the ruler supported on the side edges of the front and back panels. See that the ruler does not touch anything on the heat sinks. This is how far the inner surface of the case will be spaced from the heat sinks.

☐ 335. Set the amplifier down on its rear panel.

☐ 336. Identify the bottom of the case by the fact that it has 8 elongated holes and four, rather than eight, rows of round holes. Identify the rear of the case by looking at the top or bottom and noting the end with the largest number of holes.

☐ 337. Slide the case down over the amplifier, rear first, the bottom with the elongated holes at the bottom of the amplifier as indicated by the front-panel lettering. The case will go right past the felt ears under the front panel by pushing them toward the amplifier rear.

☐ 338. When the case is stopped by the felt ears under the rear panel, turn the assembly rightside up. Back the case off enough so you can use a screwdriver blade to push the felt edges forward and under the case. Then push the rest of the amplifier into the case. The felt prevents rattling.

☐ 339. Turn the amplifier upside down on newspaper padding. Adjust the position of the case until you can see the four threaded holes in each heat sink flange through the elongated holes in the case bottom.

☐ 340. Pass a 6-32 X ½ round-head machine screw through a No. 6 X ½ flat washer, then into one of the two center holes in either row. Do the same with the three other center holes, leaving the two ends holes in each row free.

☐ 341. Put the end of a similar screw through the center hole in a plastic foot (Fig. 2-A) from the small end. That is, the end of the screw would be up and the head down if the foot were held as it is shown in Fig. 2-A. Press the head all the way inside the foot hole as far as it will go. Then wind the screw into one of the end holes in one row under the amplifier and tighten it with a screwdriver inserted into the hole in the foot.

☐ 342. Install three more feet in the remaining end holes in the same way. Then tighten the plain screws as well.

Your amplifier is complete. Please read the following section before installing it and putting it into operation.

# INSTALLATION & OPERATION

This section tells you about physical and electrical installation of your amplifier and how to use it. There are also some notes about special tests which professionals or hobbyists may care to make, though they are not necessary.

## PHYSICAL INSTALLATION

The TR-3 can be mounted in any position. Most commonly it is simply set down on its plastic feet. The feet have high friction and the amplifier is fairly heavy—so it is unlikely to move unless the item in which it is mounted is itself subject to rather extensive and sudden movements.

The amplifier can easily be fastened down. That is usually best despite what we have said in the previous paragraph. Fig. 33 shows how the special wood blocks furnished in the kit are used for this purpose. One block is used at the rear of the amplifier and the other at the front.

If the amplifier is to be mounted on a vertical surface, the blocks are used in the same way. Screw the lower one in place first, rest the amplifier in it with the case's bottom edge in the groove; then add the upper block. The amplifier can also be hung from an overhead horizontal surface in the same way. Hang it rightside up, unless inconvenient.

If the amplifier must be stood on end because of the dimensions of the available space, use the wood blocks for that, too. In a case like that you would normally want the front panel to face up. Put both wood blocks under the down-facing amplifier rear, the grooves up, and the top and bottom edges of the rear of the amplifier case in the grooves. In this kind of installation the blocks would not be fastened down (though you could do so by drilling two additional holes at right angles to the existing ones). They would merely serve to prevent the metal of the case edges from touching the mounting surface and permit air to reach the rear panel.

The four large wood screws in the kit are supplied for attaching the wood blocks to a mounting surface, as shown in Fig. 33.

### Heat Dissipation

*PLEASE READ THIS SECTION THROUGH BEFORE MAKING ANY FINAL INSTALLATION.*

The TR-3 Amplifier generates heat whenever it is turned on, even when no signal is being amplified. It generates more heat when it is in actual use—the greater the power it is putting out and the steadier that power, the greater the heat.

It has protective devices which prevent it from being damaged by the heat. The thermostat mounted on each heat sink is a heat operated switch in series with the a.c. line. If the temperature of either heat sink reaches 200 degrees F, the thermostat is activated and the amplifier is automatically turned off. When the sink cools sufficiently, the thermostat automatically turns the amplifier on again.

In addition to the thermostats, there are the thermistors. Their function is to adjust bias automatically with heat changes so that the characteristics of the amplifier remain constant. They also limit heating by changing the bias so as to make less heating current flow as the heat sinks get hotter.

The circuit breaker is another protective device which turns the amplifier off if excessive current is drawn, which would cause too much heat and would damage the transistors. Ordinarily the circuit breaker comes into play only when rather sudden things happen, such as short circuiting an output when the amplifier is putting out high power.

In actual use, however, none of these protective devices should be required to operate. The amplifier is designed to

withstand all the heat normally generated and to keep on working. The amplifier will deliver its rated 70 watts continuously from each channel (with an 8-ohm load) without excessive heating *if it is adequately ventilated.*

If you mount the amplifier inside a totally enclosed cabinet with a large enough volume of air (perhaps 10 times the amplifier's own volume as a minimum) you will have no problem. If the cabinet's volume is any less than that, you must provide some ventilation. This does not mean you need a fan or any other fancy ventilation. It only means that air from the outside must be allowed to flow over the unit.

Simple convection is adequate. Warm air tends to rise. If, therefore, you have some holes in the cabinet under the amplifier to allow the air to enter and some more holes above it to allow the warm, rising air to exit, you have a convection cooling system. The holes need not be *directly* under and over the amplifier. In a typical cabinet, for instance, any holes over the amplifier would normally be visible and unsightly. So the upper holes can be in a side or rear.

There is one infallible and entirely harmless test that will tell you whether you have enough ventilation. If, after you install the amplifier and begin to use it, you find that after a time it suddenly stops working and it does not go on again when you press and release the circuit breaker button, but goes on again by itself after a few minutes, you can assume the thermostats took over. That means you need more air.

**IMPORTANT**: The case itself is used to radiate and get rid of heat. The case should, therefore, not be in direct contact with anything else (except the wood blocks furnished). Do not remove the four plastic feet.

Please understand that heating is not a problem with this amplifier. *Any* amplifier generates heat, especially a high-power one like the TR-3. And *all* equipment that generates any heat should be mounted so some air can flow over it as we have specified.

## ELECTRICAL CONNECTIONS

For all practical purposes a 2-channel TR-3D may be considered as two separate amplifiers. While this point is of no importance in a stereo system (though of course the large channel separation figure is an advantage), it has meaning in a Schober Organ, where one channel may be used for organ tones and the other for percussion and rhythm, or where one channel may be used for each of the manuals as in the Recital Organ. It is also of interest in some other audio applications. Where it matters, each channel can be used independently, and the interaction between them, which is solely due to the fact that a common power supply is used, is so small as to be insignificant.

Input connection to each channel is made with a phono plug at the top of the front panel. The output connections are at the binding posts at the bottom. A.c. power should be supplied to the line cord at either 50 or 60 Hz, at any voltage between about 100 and 130. If the voltage is outside these limits (as is true in many places outside the U. S. A.) a step-down transformer is necessary. So you will know how heavy a transformer to buy, the TR-3D (2-channel) amplifier draws a maximum of 340 watts from the power line. The TR-3M draws a maximum of 200. Both are at 117 volts.

In a stereo system, the *phasing* of the speaker connections is important. If your speaker systems have some sort of distinctive marking at one of the two terminals, such as one red binding post or a paint mark, the wire from that terminal of each system should be connected to the red binding post of each TR-3D output.

If you are using a pair of Schober LSS-10A Speaker Systems—which, with the HF-1 Supertweeter, produce a wider range and better quality of sound than most speaker systems sold today—the terminals are not actually marked. However, you will see that a red wire leads from inside the enclosure to one of the screw terminals and a black wire to the other one. If you will connect the terminal with the red wire to the red binding post for each speaker system and amplifier channel, the speaker systems will be correctly in phase.

This phasing should be observed in applications other than stereo systems, too—wherever both channels may be carrying signals from the same source simultaneously. This includes use in Schober Organs, in which two channels may be carrying outputs from two manuals, as in the Recital Organ, or one may have organ tones and the other percussions. Since all tones in the organ come from the same set of tone generators, cancellation can occur with out of phase speakers. This is especially important with a two-channel Recital Organ, since pedal tones can go through both channels. If the speaker systems are out of phase the low bass will be destroyed.

If your speaker terminals are not so identified, begin by connecting the speakers to the amplifier outputs at random—one wire from each speaker to a black binding post and the other from the same speaker system to the red post above it. Then turn on some *monophonic* program material and adjust your controls so sound from both speakers seems to be the same in volume at a point midway between the two.

Now turn everything off and reverse the connections of *one* speaker system—the wire formerly on the red terminal to the black one and the one formerly on the black to the red. Now listen again. The connection which gives the best bass is the correct one. And unless the speakers are unusually far apart, the correct connection is also the one which appears to place the source of sound between the two speakers rather than indeterminately out in space somewhere.

When you are using the two amplifier channels separately, with no sounds common to both, this phasing makes no difference. However, in a Recital Organ, where each channel takes care of one manual, phasing *is* important. Turn the Recital's pedal control switch on the stopboard to the BOTH position, where the pedals are heard in both speaker systems. Using low 16′ pedal notes for the tests, adjust speaker connection phasing for the best bass.

Usually ordinary twin lamp cord is used to connect the output binding posts to the speaker systems. In all cases this wire must be at least No. 18. (This means a size number of 18 *or lower*, since thicker wires have lower numbers.)

No. 18 wire will suffice for runs up to about 50 feet. For longer runs you should use No. 16 wire, the next heavier size.

To connect the wire ends to the binding posts, *do not tin the strands in the usual way.* Instead, coat only a tiny bit of the wire ends with solder to prevent the strands from straying. Unwind a post cap, pass the stripped wire through the hole in the brass post, then tighten the cap down very firmly. Only stripped wire should be under the tightened cap, *not any insulation.* The reason for not tinning the entire stripped end of the wire is that solder is soft. It will yield to the pressure of the tightened cap and will never stay well compressed.

Please be sure you make the connections at both the binding posts and the speaker terminals in such a way that no stray wire strands can cause a short circuit between the

two terminals.

If you are not using one of the two channels of a TR-3D, there is no need to insert a dummy load. Simply leave the output binding posts unconnected. There is also no harm in using different speaker systems with different impedances on the two channels—though in a stereo system this does not yield the best stereo sound.

## OPERATION

**WARNING:** The TR-3 Amplifier is capable of putting out a lot of power from each channel and, with the SENSITIVITY controls turned up it has much more gain (amplification of the input signal) than the usual power amplifier. It is capable of damaging many speaker systems (to say nothing of your eardrums) with excessive signal. When turning it on after connecting it for the first time, begin with all controls at the minimum settings. Turn them up gradually while you listen. Stop when the sound is as loud as you will ever want it to be.

Always begin with the SENSITIVITY controls fully off (counterclockwise). In that condition, the amplifier sensitivity is such that a 1-volt input from organ, stereo preamplifier, or whatever your source may be, will drive the amplifier to full output when the VOLUME control is at maximum. In most cases that sensitivity is sufficient and the SENSITIVITY controls need never be moved from minimum.

However, if you find that this setting does not give you enough volume, or that you actually have to have the VOLUME control at maximum to get enough, set the VOLUME control at about half rotation. Then advance the SENSITIVITY control as necessary to give you the maximum volume you will ever want. This leaves you with plenty of range both ways on the VOLUME control so you can make small adjustments or even use the VOLUME controls regularly if that is the nature of your installation. With the SENSITIVITY controls full on, each channel requires only .15 volt for full output, a considerably greater sensitivity than the usual power amplifier.

Do not advance the SENSITIVITY control from the fully counterclockwise position unless you actually need the additional amplification. Minimum possible distortion is obtained with sensitivity at minimum.

The output impedance of most stereo preamplifiers is low enough so you can locate the amplifier at a considerable distance from your control point, if you would like to hide the amplifier away in a closet. Be sure you use shielded cable from preamplifier to amplifier inputs. In an installation of that kind you will want to derive a.c. power from one of the switched outlets on your preamplifier; just use an extension or splice additional twin lamp cord to the TR-3's line cord. No. 18 wire is adequate for runs up to 50 feet.

The amplifier can also be used at a distance in a Schober Organ installation, but it is not necessary because the shape and dimensions of the amplifier allow it to be located in the organ console. The instructions for your particular organ model tell you where to locate it, but there is nothing critical about the location.

## SPECIAL NOTES FOR TESTERS

The following remarks are for the benefit of those who, for either professional or hobby reasons, wish to test the amplifier to see how it conforms with its specifications and to see how far it can be driven. This section has no application if your sole intention is to use the TR-3 for audio amplification as it was intended, since you can rest assured it will perform as specified and tests of this kind are totally unnecessary.

Maximum obtainable unclipped power at a line voltage of 117 depends on whether one or both channels are driven and on the output load impedance. At 16 ohms each channel delivers 50 watts, with both channels driven by sine waves, or 54 watts with one channel driven. The one-channel figure for 8 ohms is 87 watts, 78 watts per channel with both driven.

Under the latter condition, the circuit breaker *may* cut out after several minutes. However, if output is limited to the rated 70 watts from both channels, the amplifier will continue to operate indefinitely.

With 4-ohm loads, 116 watts can be obtained for a short time with one channel driven, after which the thermostat will open. With both channels driven, 100 watts can be obtained for a few seconds; then the circuit breaker will open.

Between about 10 and 40 kHz maximum available power is slightly lower and can be obtained for only a short time before the circuit breaker opens.

During all high-power testing the amplifier case becomes very hot—too hot to touch. This is correct, and the thermostats will protect the transistors from overheating.

Under ordinary circumstances shorting the output terminals will not damage the amplifier; at any power level over about ½ watt, the circuit breaker will open in about 1 to 6 seconds, depending on the power level and whether the amplifier has one or two channels. At lower power levels the breaker of a shorted amplifier probably will not open but the thermostat system *may*, in time. If it does not, the amplifier can cope with the condition indefinitely.

**WARNING:** It is not well to tickle the tiger's tail. You can short the output at full power two or three times if you really feel you must do it to demonstrate something or other; but if you try it 10 or 12 times in quick succession, before dynamic heat equilibrium has been attained, you may lose some expensive power transistors.

It should be clearly understood that tests of this kind have little to do with the intended use and performance of the amplifier, even for organ amplification, which is one of the severest tests of amplifier performance. With music and speech, especially if it has not been excessively compressed or limited, the amplifier can be operated indefinitely with the loudest signals at—or even above—the clipping level. In any normally listenable audio material these loudest portions which reach the clipping level are never long lasting enough and do not have sufficient high-frequency content to make the circuit breaker or thermostats open.

The output should never, of course, be shorted deliberately by a user; and if it happens accidentally the protective devices will operate, as they should.

# SERVICING

This section tells you what to do if your amplifier does not work right, either just after you assemble it or at some later time. Well designed solid-state equipment should operate for many years without trouble if correctly used. However, nothing in life attains perfection. It is always possible that you have made some error in following the instructions, or that over a period of time some part which did not quite meet specifications could eventually give way.

The TR-3 is designed physically in such a way that every point within it is accessable for checking and service. The printed circuit boards can easily be dismounted and folded over for access to both sides; and all connections in the unit are reachable by a test probe or soldering iron.

In addition, Schober engineering personnel have many years of experience in diagnosing electronic troubles at a distance. It is our desire, as much as yours, to see that your Schober equipment operates to your satisfaction; and we will do whatever is necessary (short of a visit to your home) to see that it does.

The Schober guarantee states that over a period of 5 years from your purchase of the kit we will replace without charge any part that is or becomes defective, through no fault of yours, and that if you follow the instructions exactly your equipment will operate as advertised.

Most problems can be solved by you with the aid of the servicing information which follows. Those that remain can usually be resolved by asking our help by mail. And any that survive that will be fixed by our laboratory if you send or bring your amplifier in to us.

## ADVICE BY MAIL

If you cannot solve a problem by yourself, do not hesitate to write to us and ask for help. When doing so, please observe the following rules. They are designed for your benefit, not ours, so that we will be able to give you a final solution as quickly as possible without repeated exchanges of correspondence.

1. Please write so we can read it. Typewrite if at all possible. We would much prefer poor typing to even the best handwriting, for obvious reasons.

2. Be sure you include your full name, complete address, and phone number. You would be surprised at how many people omit the address! (And we may possibly phone you to help speed up your repair.)

3. It is absolutely essential that you include every bit of information you can, even that which does not seem germane to the particular problem. Say what does work, as well as what does not. Recite any events that took place, any suspicions you may have, anything else you can think of to tell us.

4. Say how you are using the amplifier—what the signal source is, how high the controls are turned, where the unit is mounted, what kind of speaker systems you have, and so on.

5. If there is an occasion for a second exchange of correspondence, please repeat the background. This saves us the time to go to your file and get it and speeds up the reply.

6. You *can* telephone us instead of writing, especially if the problem or question is simple. However, if you have a real problem writing is better. It gives us a chance to think more and come up with a better than off-the-cuff answer.

## LABORATORY SERVICE

Schober maintains a service department which takes care of problems in Schober equipment. The service department is at your service if mail/phone advice does not solve the problem or if you simply don't want to undertake a repair yourself.

Please notice, however, that laboratory service costs money and is a nuisance. The nuisance is that you must pack the amplifier safely and send it to us. The money is our service charge and the transportation charges.

A separate sheet packed with your amplifier kit details the charges and procedures for factory service. Note that any amplifier returned for service must have transportation prepaid and must be accompanied by the stated service charge. That charge will be refunded if (a) the fault was not caused by you *and* (b) it could not have been corrected by you with our advice by mail or phone. Notice that this means a fault due to a bad part does not result in a refunded service charge unless, in our opinion, the bad part could not have been located and replaced if you had told us the problem and followed out repair instructions. Do not, therefore, be too quick to return an amplifier for repair!

## SAFETY MEASURES

Once you have taken the case off the amplifier, there are two kinds of safety hazards if you plug it in and turn it on—a hazard to your own health and a hazard to that of the amplifier.

Inside the amplifier some connections to the a.c. power line are exposed. All points at which a.c. line voltage exists can be identified by the fact that connections are made to them with pieces of the a.c. line cord—either parts of the existing line cord or pieces of wire cut from it. These points are dangerous *whenever the line cord is plugged in,* not just when the power switch is on. Danger also exists at the points to which the black transformer wires are connected.

When the power is on, the power supply of the amplifier generates +50 and −50 volts d.c. Touching certain points carrying these voltages can be dangerous or at least uncomfortable.

As a general rule, therefore, you should not touch any thing within the amplifier or mounted to the heat sinks when the a.c. line cord is plugged into the power source. This includes the cases of the large output transistors.

Exceptions: You may touch the power transistor cases *one at a time* to feel heat. And you may touch the large metal pieces such as the heat sinks and front and back panels.

Also, to make measurements, you may touch meter probes to connection points, making sure a probe does not slip and touch two connections simultaneously.

The second hazard, that to the amplifier itself, exists mainly because power transistors are subject to instant and catastrophic destruction if an element is connected to the wrong point or a wrong voltage is placed on one. The ways of accomplishing this are too numerous to mention. One of them, the easiest to do because of exposure, is to connect a power transistor case to the surface of the heat sink. You can do that with a metal watch strap on a passing wrist.

So stay away from the amplifier's innards as much as possible unless the power plug is pulled out of the wall socket.

## WHAT CAUSES FAULTS

It is an observation and not a prejudice when we say that almost all troubles are the fault of the kit builder. They stem from these sources:

1. Making a wrong connection.
2. Omitting a connection.
3. Poor soldering.

Of the three, poor soldering is historically the largest element. If you will watch a really good professional working at the bench, you will see that he looks closely at every solder connection after it cools, to see that the solder has fully blended into the wire and into the terminal or printed circuit copper. And this is *after* he has watched while applying the solder and iron to see that the solder is unmistakably fully melted and has puddled out and climbed over the metal. He does this because early in his career he depended a few too many times on the excellence of his technique and thereafter had to make a repair!

Not all metals are equally well "solderable." Sometimes a particular wire or terminal is not so anxious to accept solder, requires more heat than usual, or more solder. Sometimes the iron is not in good contact with one or the other, though your eyes told you it was. So only post-operative examination can tell you whether the joint was a success. And remember, the one joint in the whole amplifier which you forgot or were too lazy to examine closely is the one that will cause the trouble!

Knowing the three major causes of faults tells you what to look for initially if something is wrong. Inspect solder joints. Look for joints with no solder at all (it happens). And check connections against instructions.

It is also perfectly true that defective components occasionally (but not very often) do turn up. A later section tells you about testing them.

## SERVICING TECHNIQUES

There are three principal diagnostic techniques—and of course diagnosis is the whole point because the actual repair, when you find what is wrong, rarely takes longer than a minute or two.

*Visual inspection* is the first. Look over everything very carefully, focusing on individual points, not the panoramic view. Find the solder joint that does not look exactly right, the solder on a printed circuit board that bridges two points not already connected by copper. (The almost symmetrical layout of these boards helps here; look for anything on one half that seems different from the other half. Compare the two boards, too, if you have a 2-channel amplifier.)

Look for *anything* that does not immediately make sense. Being familiar with electronics helps here, but even without that you can spot a wire touching metal or another wire, for instance. If in doubt, look in the instructions.

*Voltage measurement* is often a valuable tool if you have or can borrow a voltmeter. A table of voltages is on page 31.

*Component testing* is a final method, used after you have localized the trouble and suspect a faulty part. A later section tells you how to test parts (page 29).

## TROUBLESHOOTING LIST

This section lists a number of possible performance troubles, each followed by one or more possible causes. Each of the numbered symptoms is in bold-face type. The possible causes are listed under each symptom with letters, in ordinary light-face type.

Try to be sure that the symptom as listed conforms *exactly* to the trouble you have.

When you are sure you have found an exact description of your symptom, try the corrective action indicated by the listed causes. Try the remedies in the order given; the easiest to do or the most probable are listed first.

Where a wiring defect is mentioned, it can mean that a wire is connected to the wrong point, broken, poorly soldered, or not soldered at all.

Except as stated, all references are to both 1- and 2-channel amplifiers.

The word "open" means lack of a connection where there should be one. An open can result from a broken or unsoldered connection, as well as referring to a component (usually a capacitor) which is internally defective in such a way that it might not exist at all. (This is in contradistinction to a capacitor that is shorted, one with an internal fault that makes it effectively into a plain closed connection between its two wires.)

Where a component may be faulty, look in the section on testing components. You may be able to test it. If not, you can request a replacement from Schober. (You can sometimes get a replacement locally, but this is not always a good idea unless you are sure it is identical.)

If you try the remedies suggested here and they do not work, be sure to tell us what you have done when you write.

**1. Amplifier dead. Pilot light in switch does not go on when switch is turned on.**

A. Line cord not plugged in.

B. Outlet into which line cord is plugged is defective.

C. Circuit breaker button has not been pressed and released.

D. Incorrect wiring of a.c. power circuitry—anything connected to or using line cord and the black transformer wires. Check against instructions.

E. Defective (open) circuit breaker.

F. Defective (open) thermostat.

G. Defective (open) power switch.

**2. Circuit breaker clicks out instantly when power switch is turned on.**

A. Error in wiring line cord or associated wiring. Check against instructions.

B. Error in power supply wiring (red and yellow wires).

C. Rectifier mounted on rear panel may be defective.

D. A 6,000-mfd can capacitor may be shorted.

E. Defective power transformer.

**3. Circuit breaker clicks out soon after power is turned on, but not instantly.**

A. Defective transistor 54,55, 66, or 67.

B. A thermistor wrongly connected (check red dot positions and wire connections against Figs. 19, 23, 24, and 26 and associated construction steps) or open.

C. Wiring to printed circuit terminals defective.

**4. Entire amplifier is dead but power switch lights up.**

A. Error in a.c. wiring.

B. Error in power supply wiring (red and yellow wires).

**5. Entire 1-channel amplifier or one channel of 2-channel amplifier is dead, but power switch lights up.**

A. Volume control not turned up.

B. Speaker not connected.

C. Input cable or plug at either end defective.

D. Connection missing or poorly soldered to back of

input jack.

E. A 10-mfd nonpolarized capacitor on back of front panel may be open or badly connected.

D. Capacitor 3, 22, or 46 on printed board may be shorted.

E.The .1-ohm rectangular resistor on the tie point near the thermostat may be open or badly soldered.

F. Capacitor 1 on the printed board may be open.

**6. Very low output on one channel. May be distorted.**

A. Capacitor 3, 22, 46, or 61 may be shorted.

B. Capacitor 1, 72, or 74 may be open.

C. 10-mfd capacitor at volume control may be open.

D. Possible defective transistor 11, 12, 18, 19, 35, 36, 42, or 43.

E. Capacitor 25, 26, 50, or 51 may be open.

**7. D.c. voltage between .75 and 10.0, either positive or negative, appears between output posts of one channel, with nothing but the meter connected to the binding posts.**

Capacitor 72 or 74 may be shorted.

**8. D.c. voltage greater than 10.0, red post positive with respect to black, appears at output of one channel, with only the meter connected.**

A. Transistor 12, 19, 36, 43, 55, 67 on printed board or a transistor on heat sink may be defective.

B. The .2-ohm resistor connected from rectifier to the affected side of the amplifier may be open.

C. Capacitor 26 or 51 may be shorted.

D. Wiring to printed board terminal NB or B– may be defective.

**9. Same as No. 8 but voltage is negative at red post.**

A. Transistor 11, 18, 35, 42, 54, or 66 on printed board or an output transistor on heat sink may be defective.

B. The .2-ohm resistor on the transistor socket or the one on the single tie point on the transformer chassis may be open.

C. Capacitor 25 or 50 may be shorted.

D. The wire to board terminal PC, PB, or B+ may be defective.

## COMPONENT TESTING

You can test many of the components in the amplifier if you suspect they may be defective. Some can be tested by substitution—that is, by removing the suspected part and inserting one of the same type and value. If the circuit then works, you can assume the unit removed was bad. (This is not, of course, necessarily so. You may have had a bad solder connection when putting the original one in and made a good connection when inserting the substitute!) If you have a 2-channel amplifier, and just one of the channels is giving trouble, you can usually obtain the needed substitute by robbing the good channel.

When you remove something from a printed circuit board, do it with great care to avoid damaging the copper foil. Be sure you have thoroughly melted the solder before trying to pull out a wire. When you have done so, clear the hole for the new wire by melting the solder and twirling the point of a nail in the hole (from the copper side) until the solder hardens. (A steel scriber is also handy for this, as solder will not usually stick to it.)

It is extremely useful to have a voltohmmeter. If you don't have one, you can usually borrow one. You can use the ohmmeter function to check shorted capacitors and transistors and the voltage function to check the amplifier's voltages. Diodes can be checked with the ohmmeter, too.

The following subsections give you some data on testing the various kinds of parts.

**WARNING:** When you go into the amplifier, for testing or to remove or replace a part, pull out the a.c. plug—don't merely turn off the power switch.

### Transistors

The transistors in the power section of the amplifier should *not* be tested by substitution. These transistors are expensive. If one channel is not working because these transistors, or one of them, have been destroyed, substitution will only destroy the new set as well since you have not discovered and removed the cause of destruction. The transistors you should *not* substitute are: 54, 55, 66, and 67, and the large ones on the heat sinks.

You can safely check the others by substitution—by taking one out of its socket on a good channel and trying it in the same position in a bad channel.

You can use an ohmmeter to check a 40411 output transistor. While it will not tell you about the exact characteristics of the transistor, it will tell you whether it is still a transistor or has become a piece of junk.

Take the transistor out of its socket. Note that each transistor has three connections. On these large power transistors, the case is one of the connections, the pins the other two.

Usually you can use the lowest ohms scale on your meter, but if you don't get good results, go up to a scale where you do. Particular resistance values do not matter.

Make three tests for each transistor, each test involving a different pair of wires or connections. It makes no difference how you pair them or which connections you use, as long as each wire or connection has been tested against some other.

In each case, connect the ohmmeter to the two connections of the transistor; then reverse the connections. In one direction the meter should read some fairly low value of resistance, and in the other a value many times higher, perhaps even enough not to move the needle. The low reading *should not be zero on the lowest ohms scale.*

If you get a zero reading, if the reading is the same in both directions, or anywhere remotely approaching the same, or if you get no reading in either direction on any one pair of wires, the transistor is no good. If for every pair you get one rather low, but not zero, reading and one reading many times higher, you can assume the transistor is good, since there is little likelihood that a change in its detailed characteristics could have taken place.

Replace transistors carefully in their sockets. When you replace power transistors, see that no dirt specks are on the transistor bottom, on the insulator, or on the heat sink, and that there is still a good film of grease on both sides of the insulator.

The 045000 and 045500 transistors are specially made for Schober and cannot be obtained elsewhere. The others can; but unless you are in a tearing rush we suggest you get them, too, from us, as often transistors with the same numbers can have different quality and characteristics.

### The Rectifier

Before testing the rectifier, disconnect everything from it.

Test with the ohmmeter. Make four tests, each between

two *adjacent terminals.* Each test requires you to connect the ohmmeter to the two terminals, then reverse the connections.

With the meter connected one way, resistance in each case should be rather low, perhaps in the area of 8 to 10 ohms, though this depends on the meter you use. In the other direction the resistance should be almost or actually infinite. If your low reading is not 8 to 10 ohms, it is still all right if it is about the same for each pair of terminals. No reading should be zero.

Now make the same test between the red-dotted terminal (may be marked +) and the one opposite (not adjacent). The reading one way should be very high or infinite and the other very low, but not so low as between adjacent terminals.

Finally, test the remaining two. Resistance should be infinite *both* ways.

### Diodes

Diodes are checked with the ohmmeter. They need not be disconnected from the circuit board in this amplifier for testing.

Each diode is tested by connecting the ohmmeter in both directions. In one direction the reading should be low, between about 5 and 100 ohms, depending on the meter. In the other direction the reading should be many times higher or infinite. (If the diode is tested with at least one wire actually disconnected, the high reading should be infinite.)

If you are in any doubt about readings on a particular diode in a 2-channel amplifier, test the corresponding diode in the other channel's circuit board to see that they read about the same.

### Resistors

Original defects in composition resistors (the cylindrical ones) are so rare that you can forget about them.

Resistors can be damaged through overheating if there is something else wrong in the circuit or if the wrong value has been chosen. If that happens, the resistor's appearance will give it away. It may look burned, it may actually crack, and/or the color bands may have changed their appearance. If you think one *may* look bad but you are not sure, you can check its resistance with the ohmmeter after disconnecting one wire of the resistor. Do not expect the reading on your ohmmeter to be exact; anything within about 30% of the nominal resistance value can be considered all right.

If you find a damaged resistor, you must of course replace it. But don't stop there. You must find the cause of the burning and fix that, or the new resistor will burn up, too—and the amplifier will still be defective.

**NOTE**: The 2-watt resistors on the copper side of each printed board are intended to run very hot. Even if you can't keep your finger on one, don't take this as a defect.

The rectangular power resistors in the amplifier have resistances too low to measure on most meters. The only probable defect they may have is to be open, meaning infinite resistance. If they show some very low value, they are all right.

### Capacitors

The simplest capacitor test is made with the ohmmeter. If you suspect a capacitor may be shorted, remove one wire from the circuit board and check resistance. A mylar or disc capacitor should show infinite resistance. An electrolytic should show some finite resistance which slowly rises as you watch the needle, with a lower value in one direction of the ohmmeter connection than in the other. (Higher resistance should be reached with the + meter lead connected to the + end of the capacitor.) A very low, constant, reading of an electrolytic indicates a short. An infinite reading is an open. Use one of the higher meter ranges for testing electrolytics.

Nonelectrolytic capacitors from about .1 mfd up can be tested for opens. Disconnect one wire. Set the ohmmeter to its highest range. Touch the meter leads to the capacitor wires. Immediately, without touching the wires with your fingers, reverse the meter leads and touch the wires again. The needle should flicker slightly, then go to infinity.

The best check for a capacitor is a regular capacitor checker which indicates values, generally a bridge. If you use one of those, remember that capacitor tolerances are often as great as −10%, +150%. If something is wrong with a capacitor, it is generally not that the value is wrong; it is an open, short, or leakage, all of which indicate in these testers.

### The Power Transformer

Check the power transformer with the ohmmeter after disconnecting at least one black and one red wire. *Be sure the line cord has been disconnected from the outlet.*

You should get the following resistance readings, within reasonable tolerance:

1 ohm between the black wires.

0.4 ohm between the red wires.

Infinite resistance between either red and either black.

Infinite resistance between either black and the yellow.

Infinite resistance between any wire and the case.

For the last three measurements use your highest meter scale. For the last one connect to the case by scraping some point clean of paint, down to bright metal.

If your meter does not clearly show readings as low as .4 ohms, don't worry as long as the needle is slightly above zero and the reading between the black wires is higher than between the red wires.

### Power Switch

Pull out the power plug.

A good switch shows zero ohms between terminals 15 and 16 (Fig. 9) with the switch ON, infinity with switch OFF.

With the switch in either position, you should read infinite resistance between 15 and 17 or 16 and 17.

### The Circuit Breaker

Pull out the power plug.

Connect the ohmmeter leads to the two prongs of the power plug. Turn the power switch ON. You should read about 1½ ohms (assuming your power transformer is good).

Hold down the circuit breaker button. You should read infinity. Release it. You should read about 1½ ohms again.

Connect the ohmmeter directly to the two breaker terminals. You should read about ½ ohm.

You cannot check the breaker to see whether it opens at its rated current.

## VOLTAGE MEASUREMENTS

The following table lists the correct voltages in a working amplifier channel. You must use a meter with a sensitivity of 20,000 ohms per volt or greater. The ideal meter is a vacuum tube voltmeter or its solid-state equivalent with several megohms input resistance.

If you make voltage measurements but still need to consult Schober about your amplifier, be sure to include a list of your readings, plus the make and model of your meter.

Do not expect to get exactly the readings shown. With an electronic meter, accept errors as large as 20%; with a 20,000-ohms-per-volt multimeter increase that to 30%.

The table lists the readings on the three terminals of each transistor. All these terminals can be identified and reached on the copper sides of the printed circuits, where the number of each transistor is shown and the three connections—E (emitter), B (base), and C (collector) are shown in small copper letters next to the solder connections.

For the two power transistors mounted on the heat sink, you measure the three elements at tubular terminals on the printed board. These terminals are identified in parentheses in the table.

Note that there are both + and − readings. The reference point, to which the meter lead of the opposite polarity is to be connected, is the heat sink.

| TRANSISTOR | EMITTER | BASE | COLLECTOR |
|---|---|---|---|
| 11 | + .18 | + .83 | +12.9 |
| 12 | − .18 | − .83 | −12.9 |
| 18 | +13.5 | +12.9 | ± .02 |
| 19 | −13.5 | −12.9 | ± .02 |
| 35 | + .36 | + .95 | +23.4 |
| 36 | − .36 | − .95 | −23.4 |
| 42 | +24.0 | +23.4 | + .81 |
| 43 | −24.0 | −23.4 | − 1.04 |
| 54 | + .28 | + .81 | +46.0 |
| 55 | − .44 | − 1.04 | −45.7 |
| 66 | +46.6 | +46.0 | + .48 |
| 67 | −46.3 | −45.7 | − .19 |
| 90 | ± .05(OT) | + .48(PB) | +46.9(PC) |
| 91 | −46.9(B−) | −46.4(NB) | ± .05(OT) |

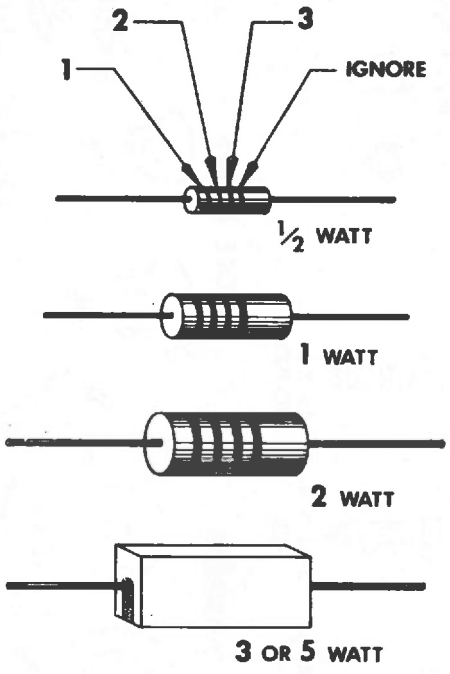



FIGURE 1

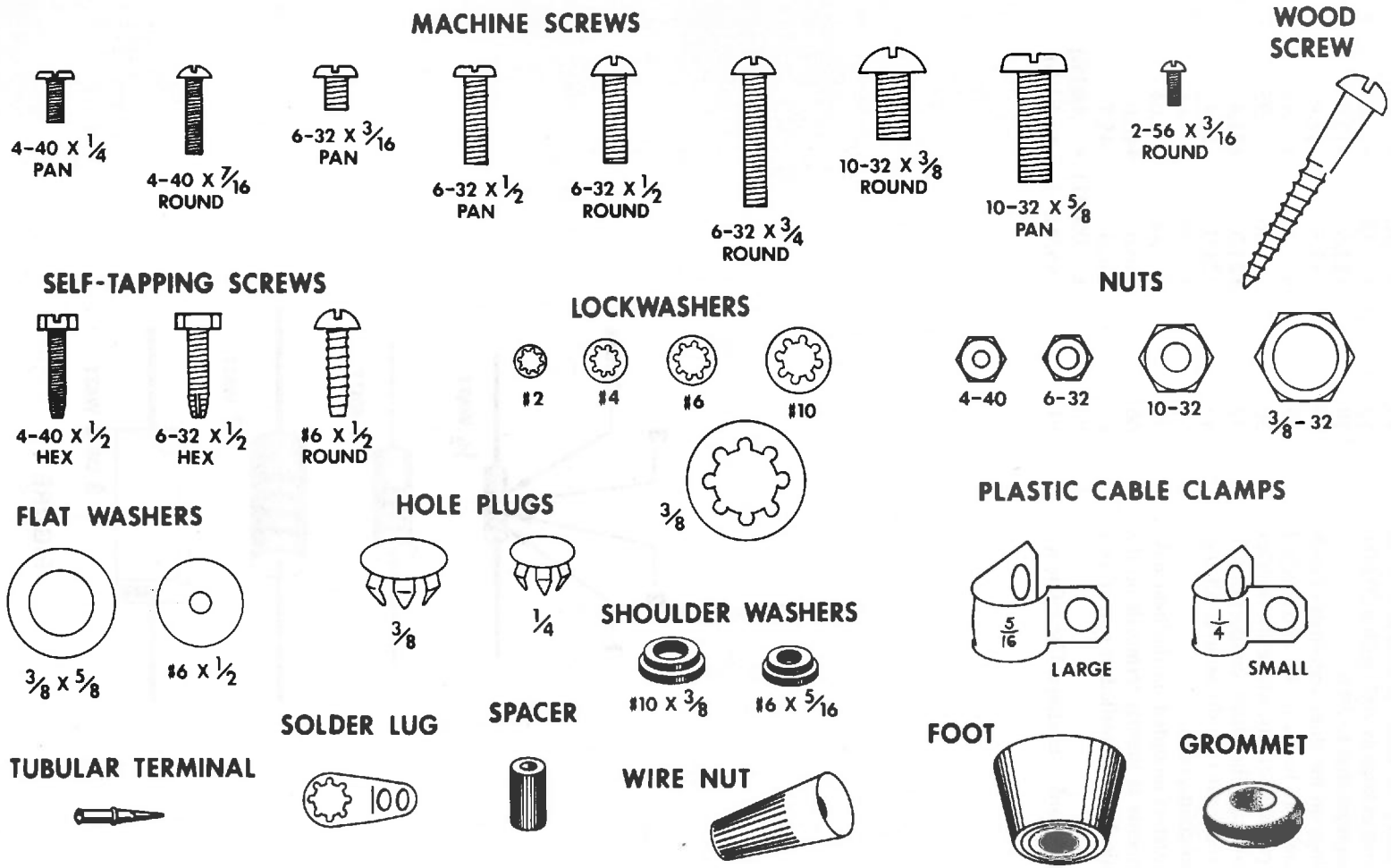

MACHINE SCREWS
4-40 X 1/4 PAN
4-40 X 7/16 ROUND
6-32 X 3/16 PAN
6-32 X 1/2 PAN
6-32 X 1/2 ROUND
6-32 X 3/4 ROUND
10-32 X 3/8 ROUND
10-32 X 5/8 PAN
2-56 X 3/16 ROUND
WOOD SCREW
SELF-TAPPING SCREWS
4-40 X 1/2 HEX
6-32 X 1/2 HEX
#6 X 1/2 ROUND
LOCKWASHERS
#2
#4
#6
#10
3/8
NUTS
4-40
6-32
10-32
3/8-32
FLAT WASHERS
3/8 X 5/8
#6 X 1/2
HOLE PLUGS
3/8
1/4
SHOULDER WASHERS
#10 X 3/8
#6 X 5/16
PLASTIC CABLE CLAMPS
5/16
LARGE
1/4
SMALL
SOLDER LUG
100
SPACER
FOOT
GROMMET
TUBULAR TERMINAL
WIRE NUT

FIGURE 2-A

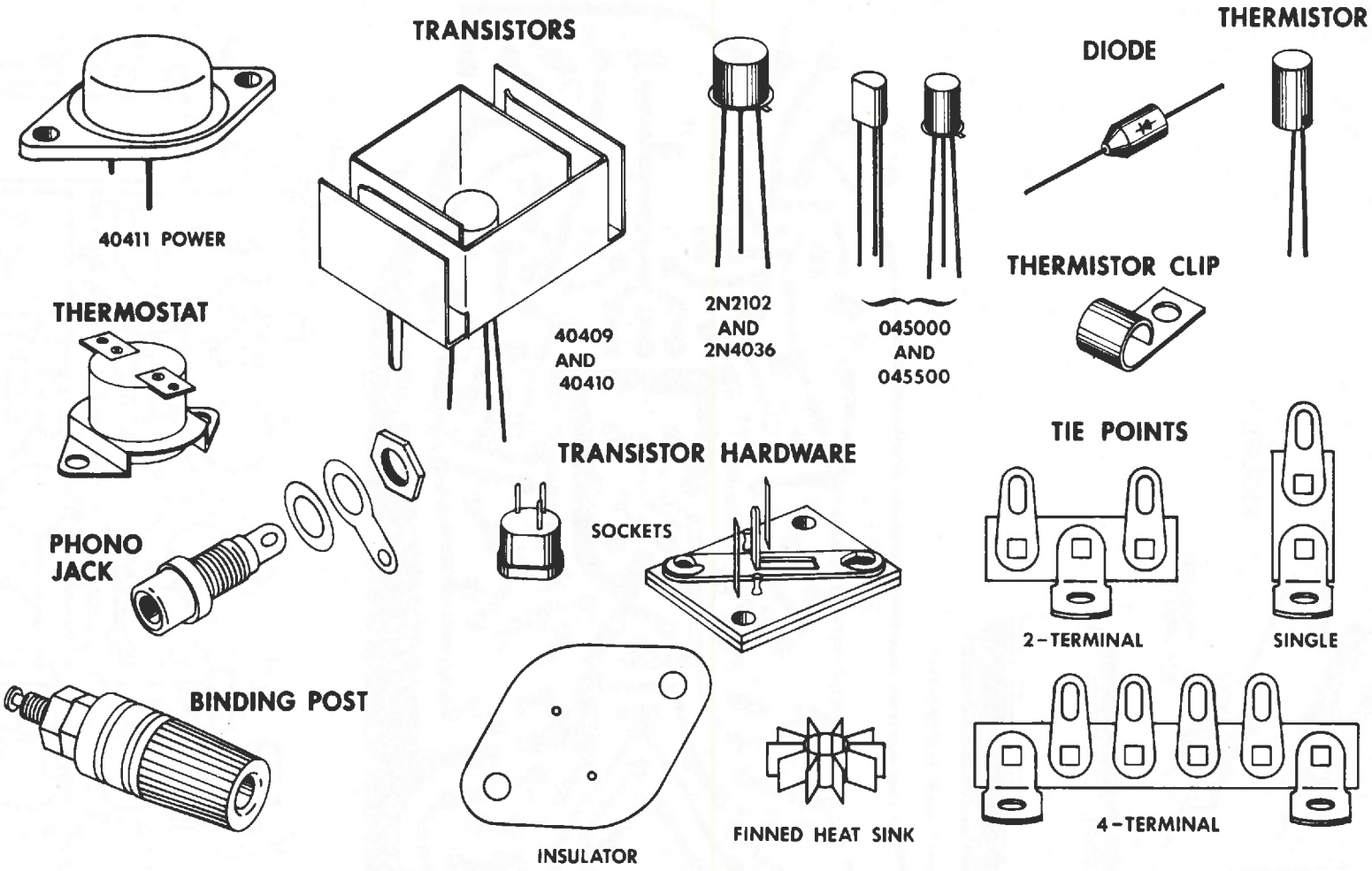

TRANSISTORS
THERMISTOR
DIODE
40411 POWER
40409
AND
40410
2N2102
AND
2N4036
045000
AND
045500
THERMISTOR CLIP
THERMOSTAT
TRANSISTOR HARDWARE
TIE POINTS
PHONO
JACK
SOCKETS
2-TERMINAL
SINGLE
BINDING POST
INSULATOR
FINNED HEAT SINK
4-TERMINAL

FIGURE 2-B

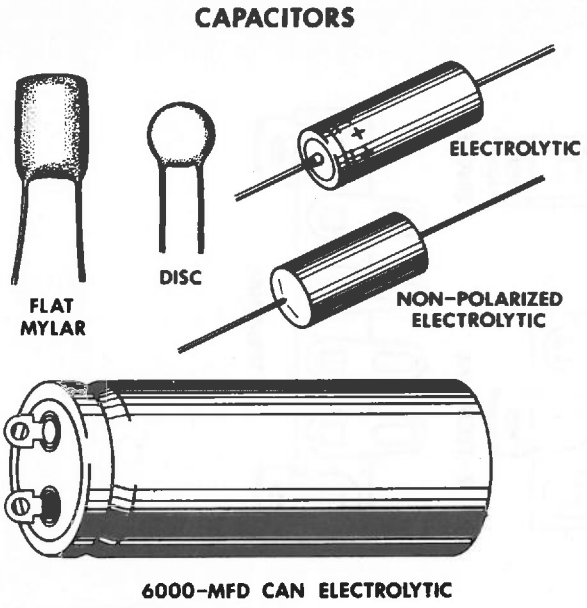
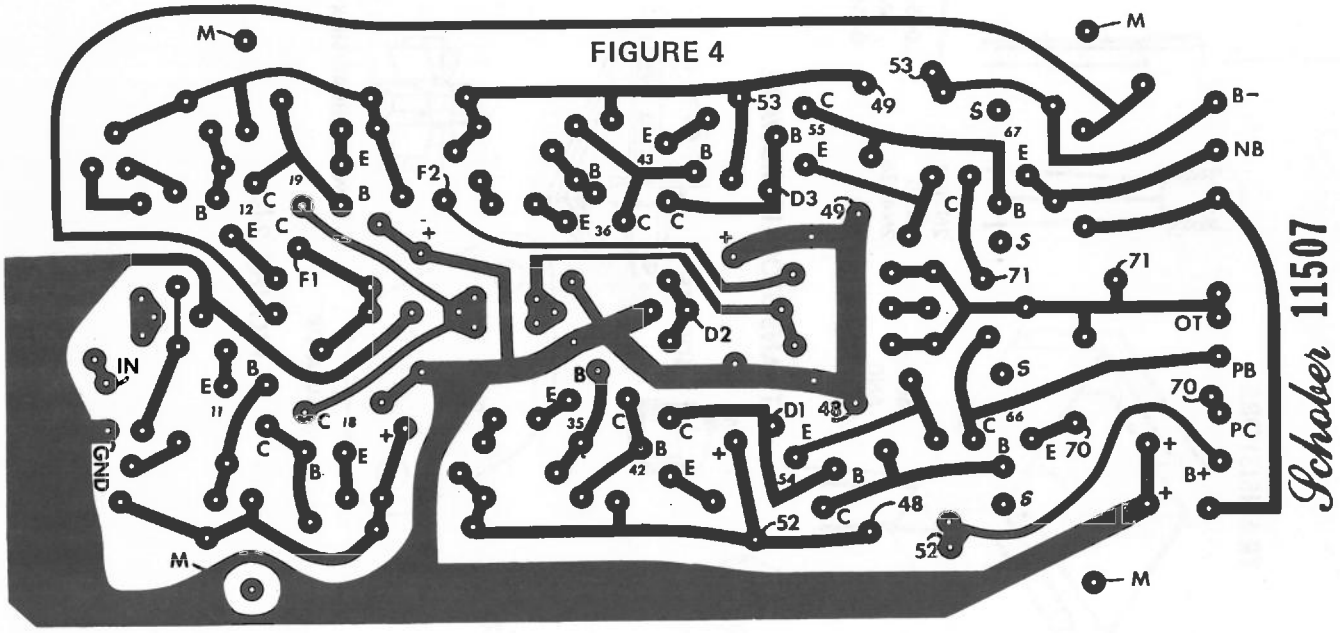



FIGURE 3

FIGURE 4



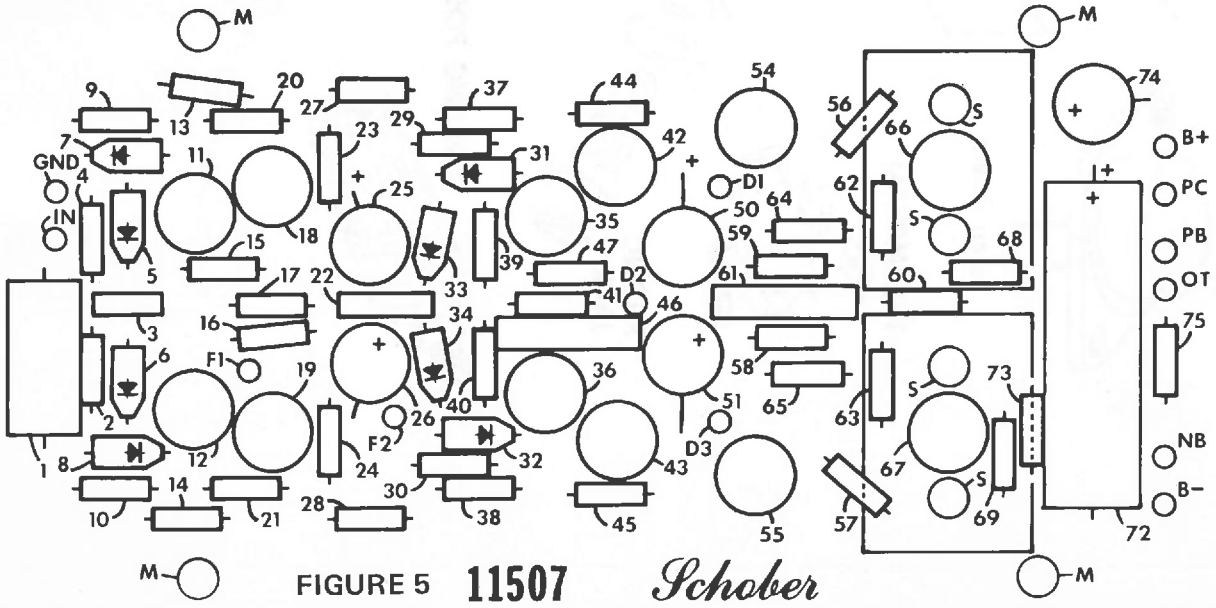




FIGURE 5 **11507** *Schober*

FIGURE 6

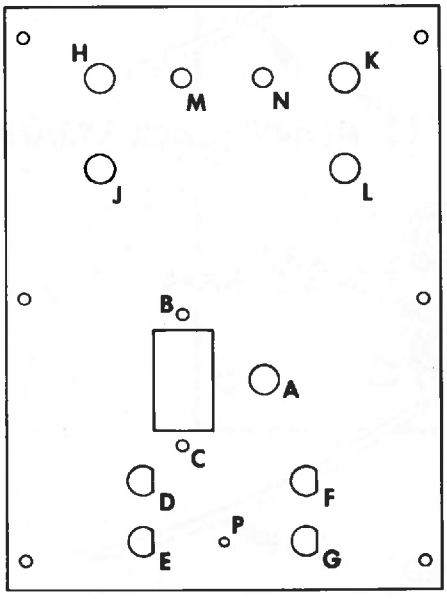



FIGURE 7

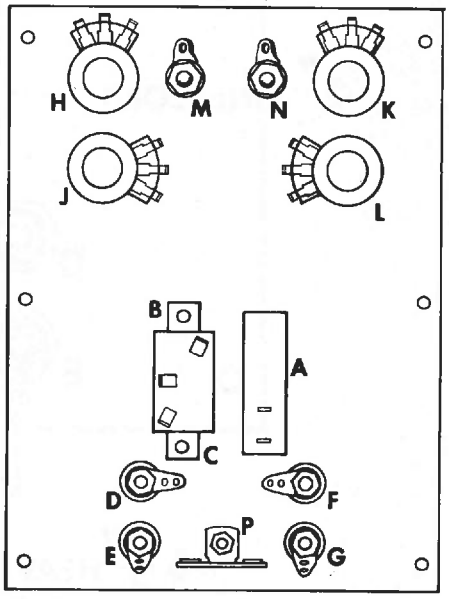



FIGURE 8

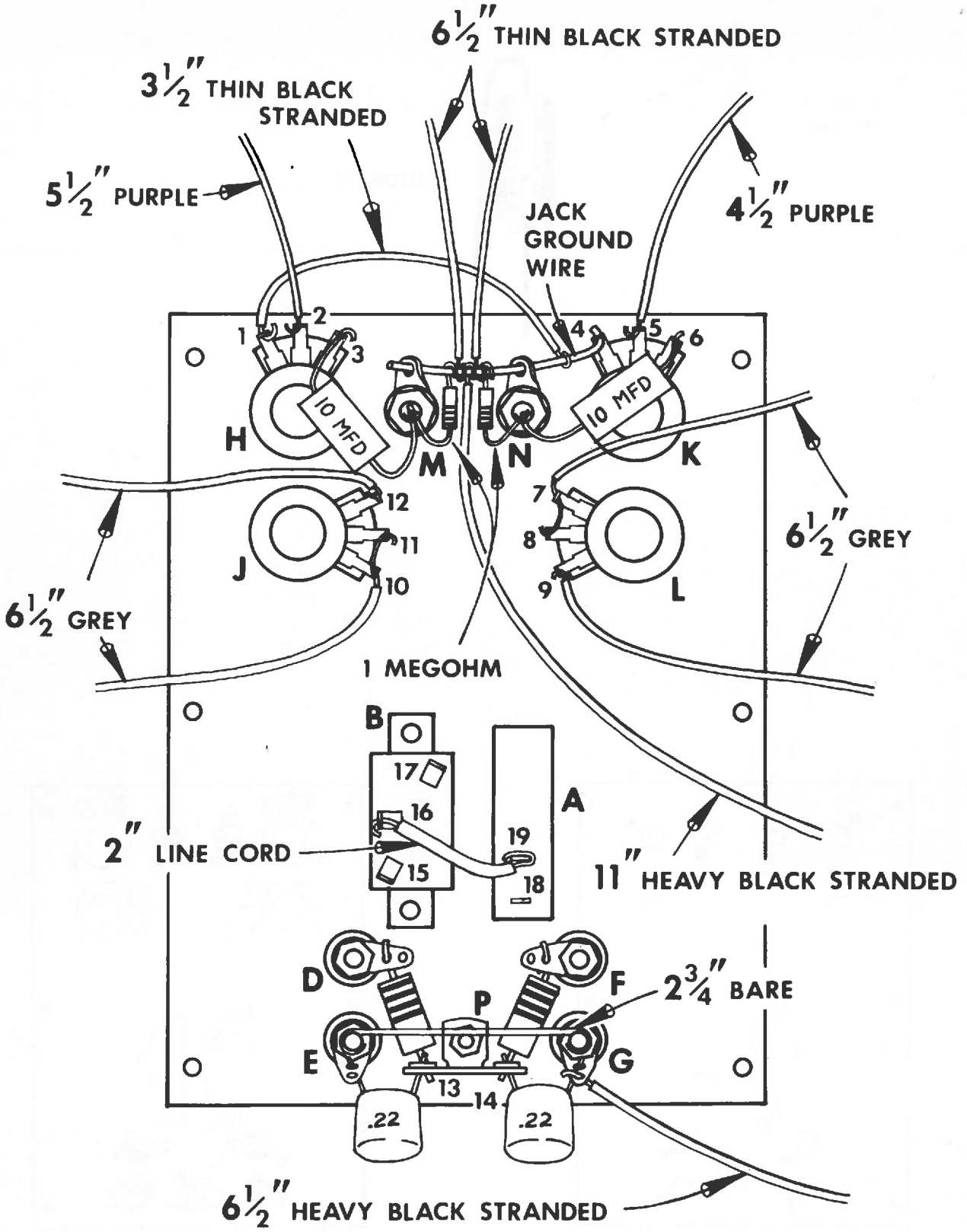

6½" THIN BLACK STRANDED
3½" THIN BLACK STRANDED
5½" PURPLE
4½" PURPLE
JACK GROUND WIRE
1
2
3
4
5
6
10 MFD
10 MFD
H
M
N
K
7
8
9
12
11
10
J
L
6½" GREY
6½" GREY
1 MEGOHM
B
17
16
15
19
18
A
2" LINE CORD
11" HEAVY BLACK STRANDED
D
P
F
2¾" BARE
E
G
13
14
.22
.22
6½" HEAVY BLACK STRANDED

FIGURE 9

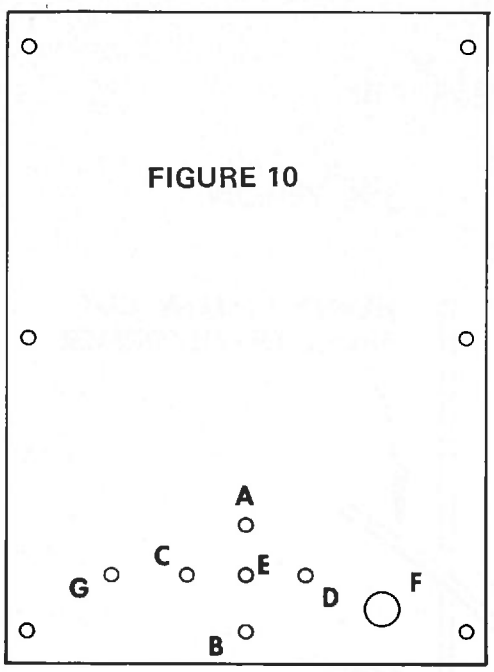



FIGURE 10

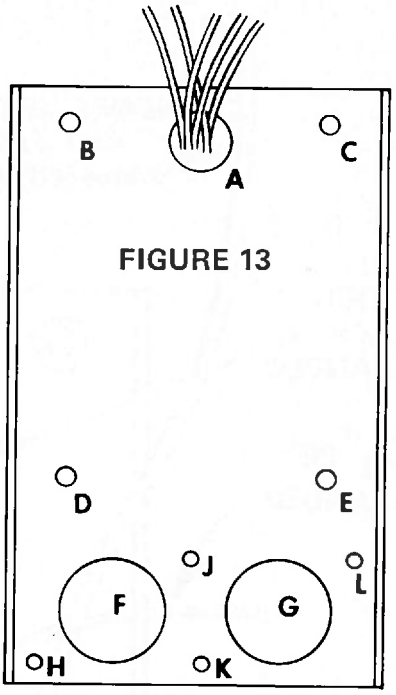



FIGURE 13

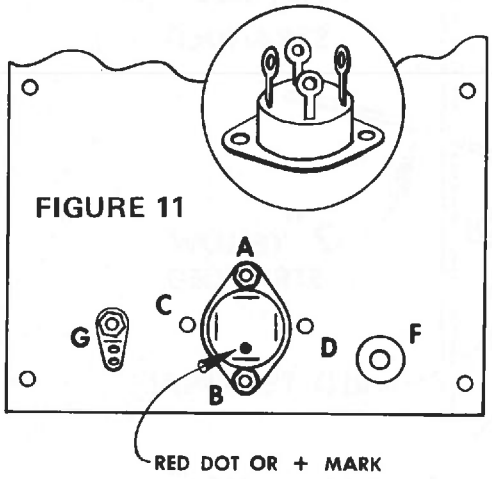



FIGURE 11

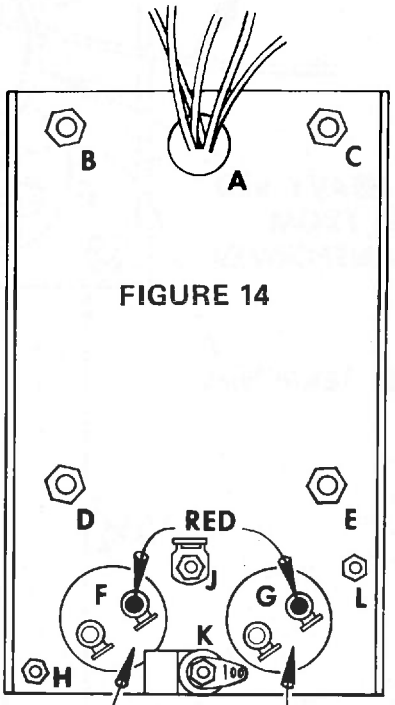



FIGURE 14

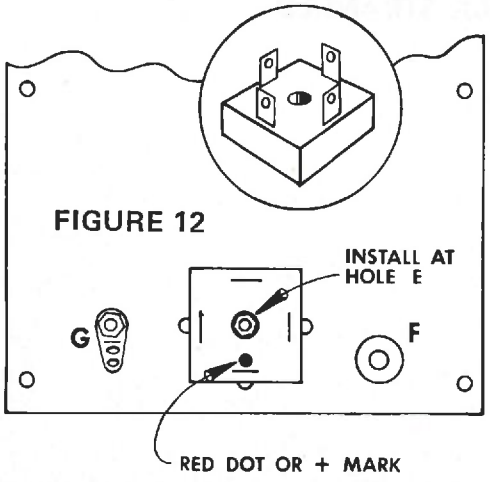
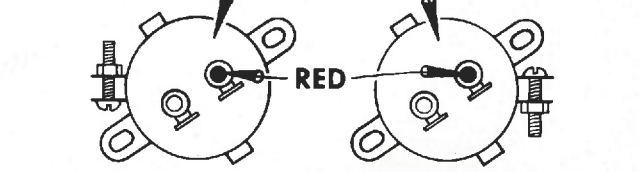



FIGURE 12



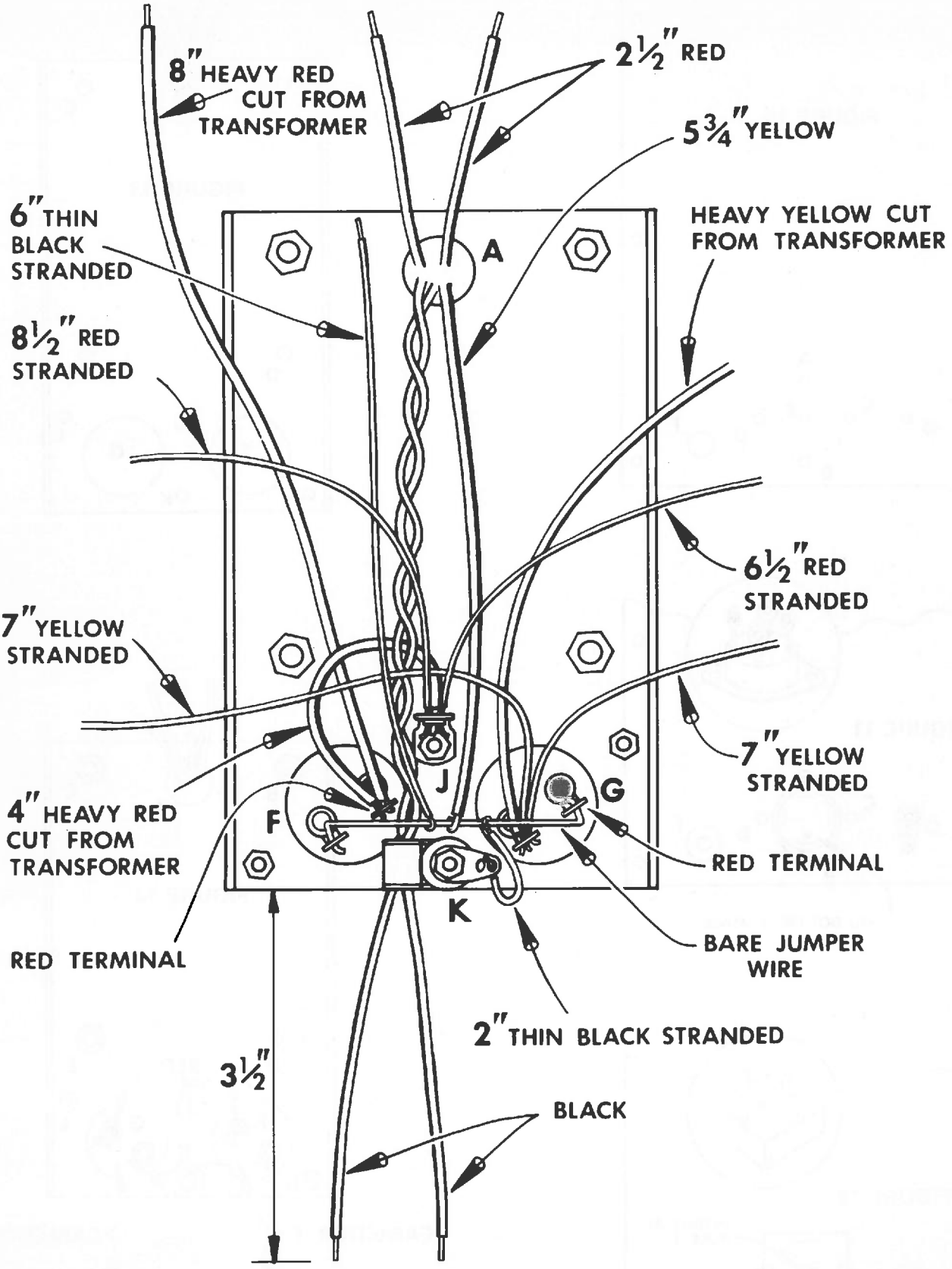

8" HEAVY RED CUT FROM TRANSFORMER
2½" RED
5¾" YELLOW
6" THIN BLACK STRANDED
HEAVY YELLOW CUT FROM TRANSFORMER
8½" RED STRANDED
A
6½" RED STRANDED
7" YELLOW STRANDED
7" YELLOW STRANDED
J
G
4" HEAVY RED CUT FROM TRANSFORMER
F
RED TERMINAL
K
BARE JUMPER WIRE
RED TERMINAL
2" THIN BLACK STRANDED
3½"
BLACK

FIGURE 15

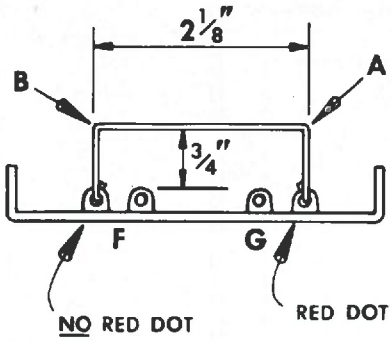



FIGURE 16

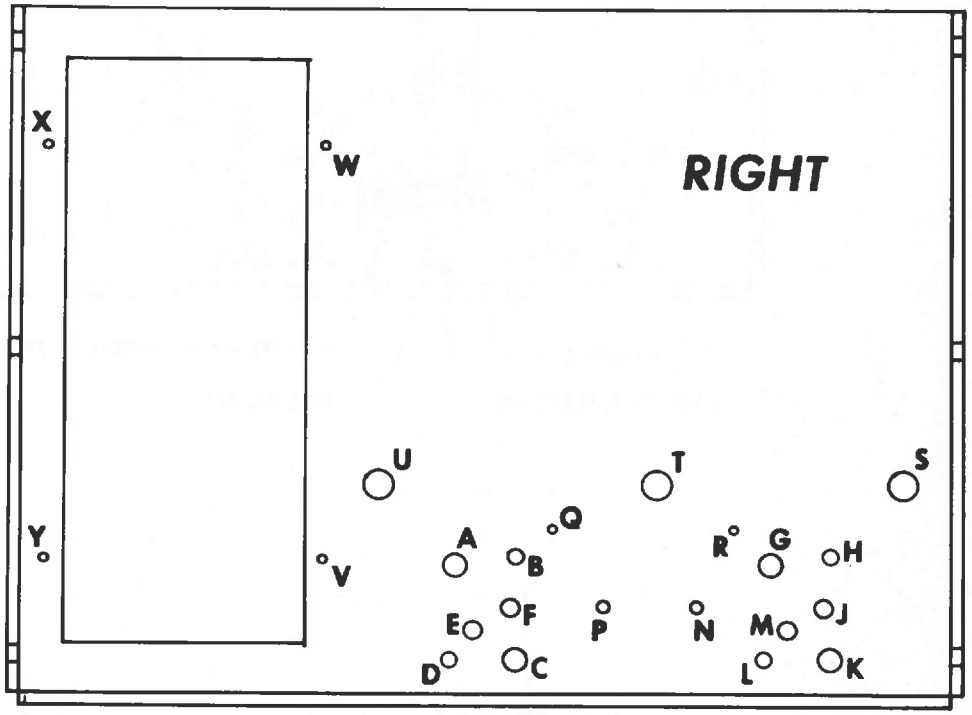



FIGURE 17

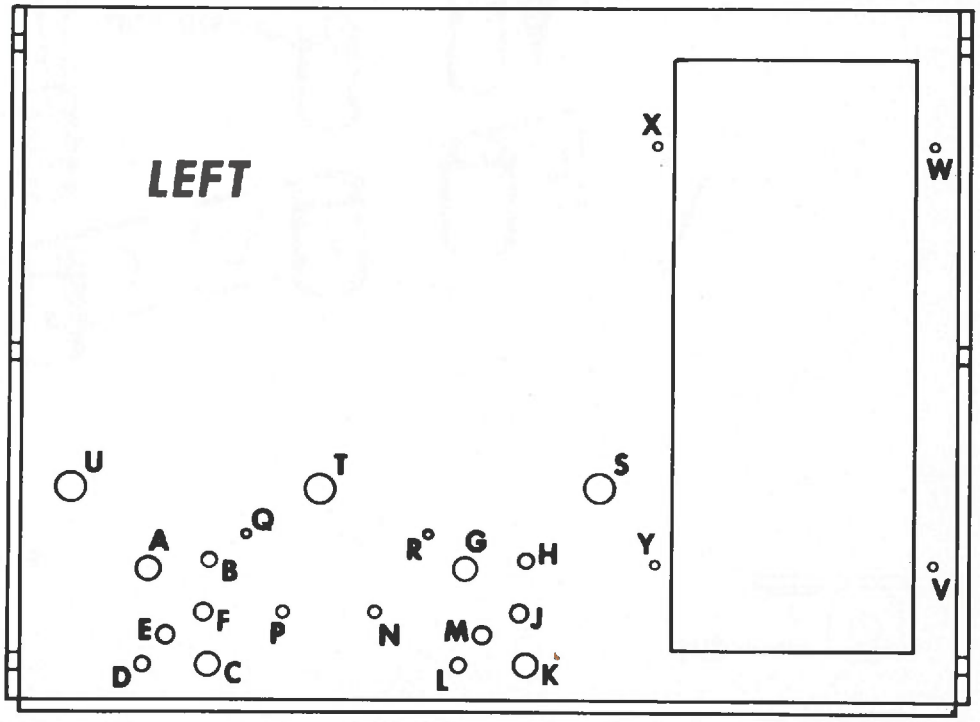
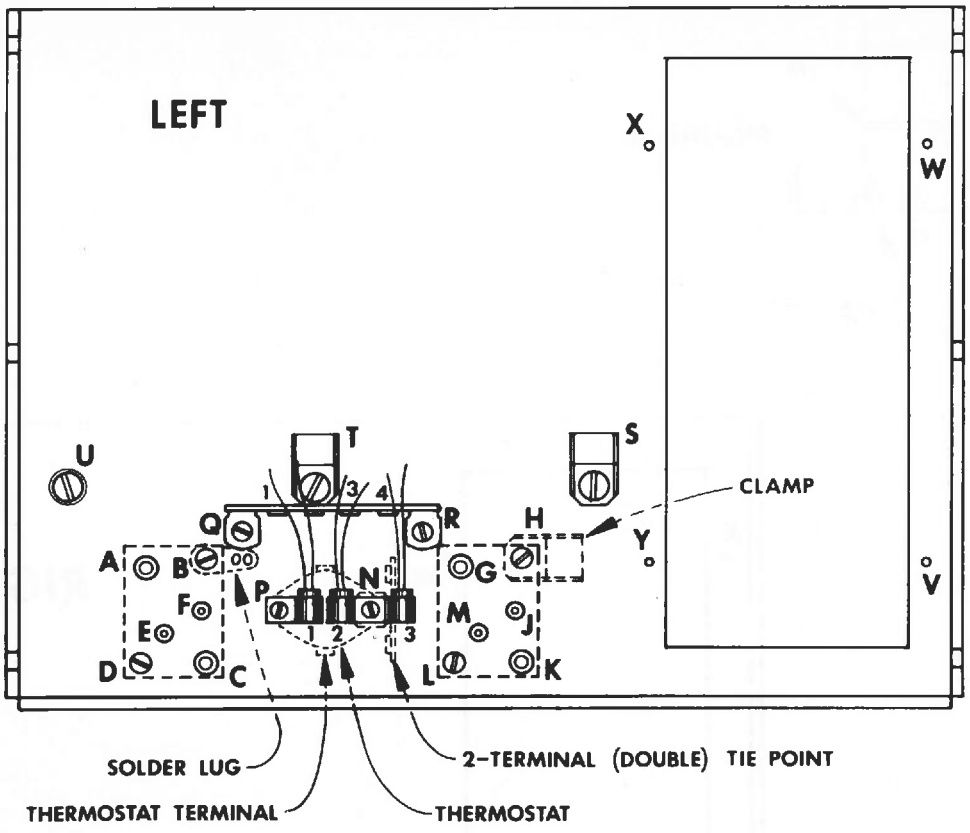


FIGURE 18



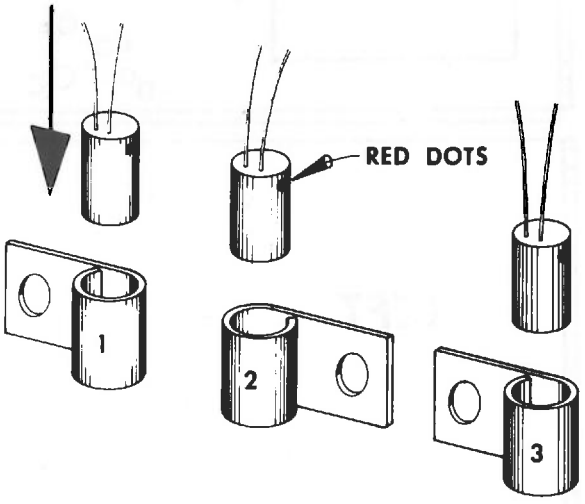




FIGURE 19

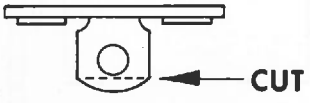



FIGURE 20

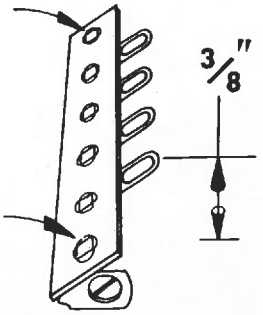



FIGURE 21

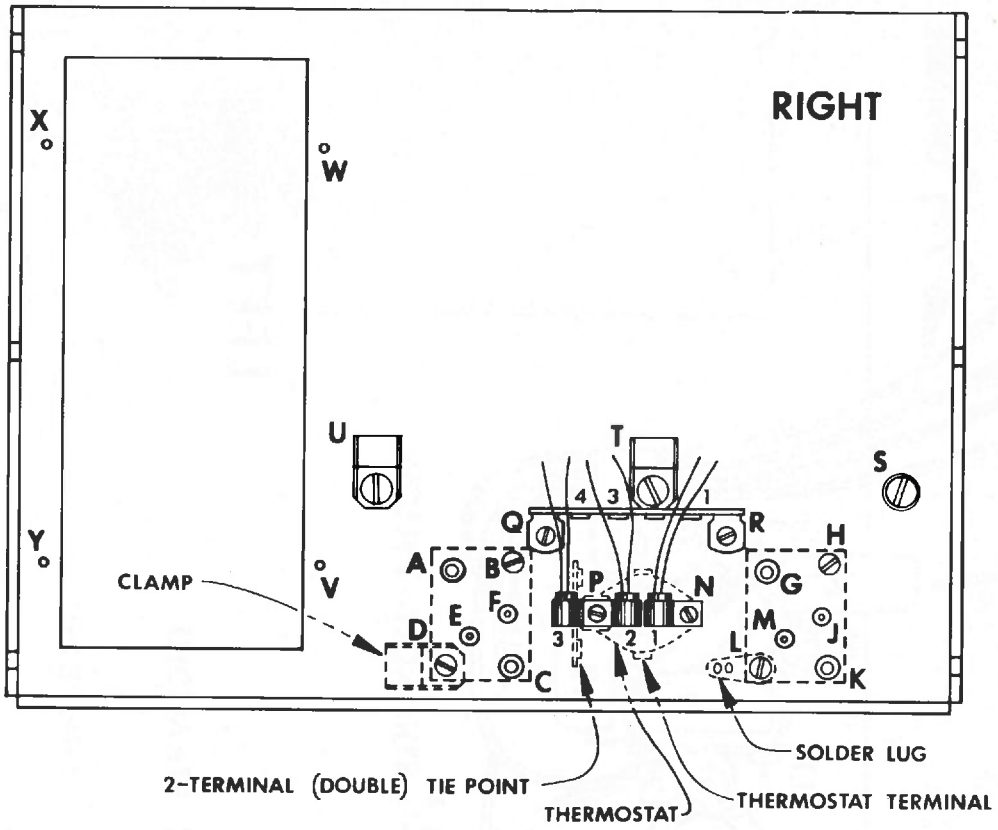



FIGURE 22

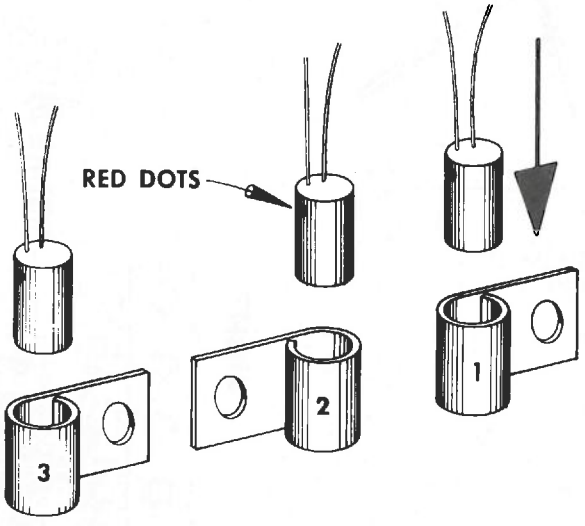



FIGURE 23

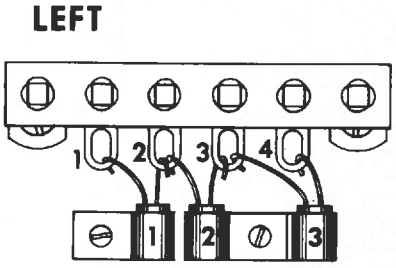



FIGURE 24

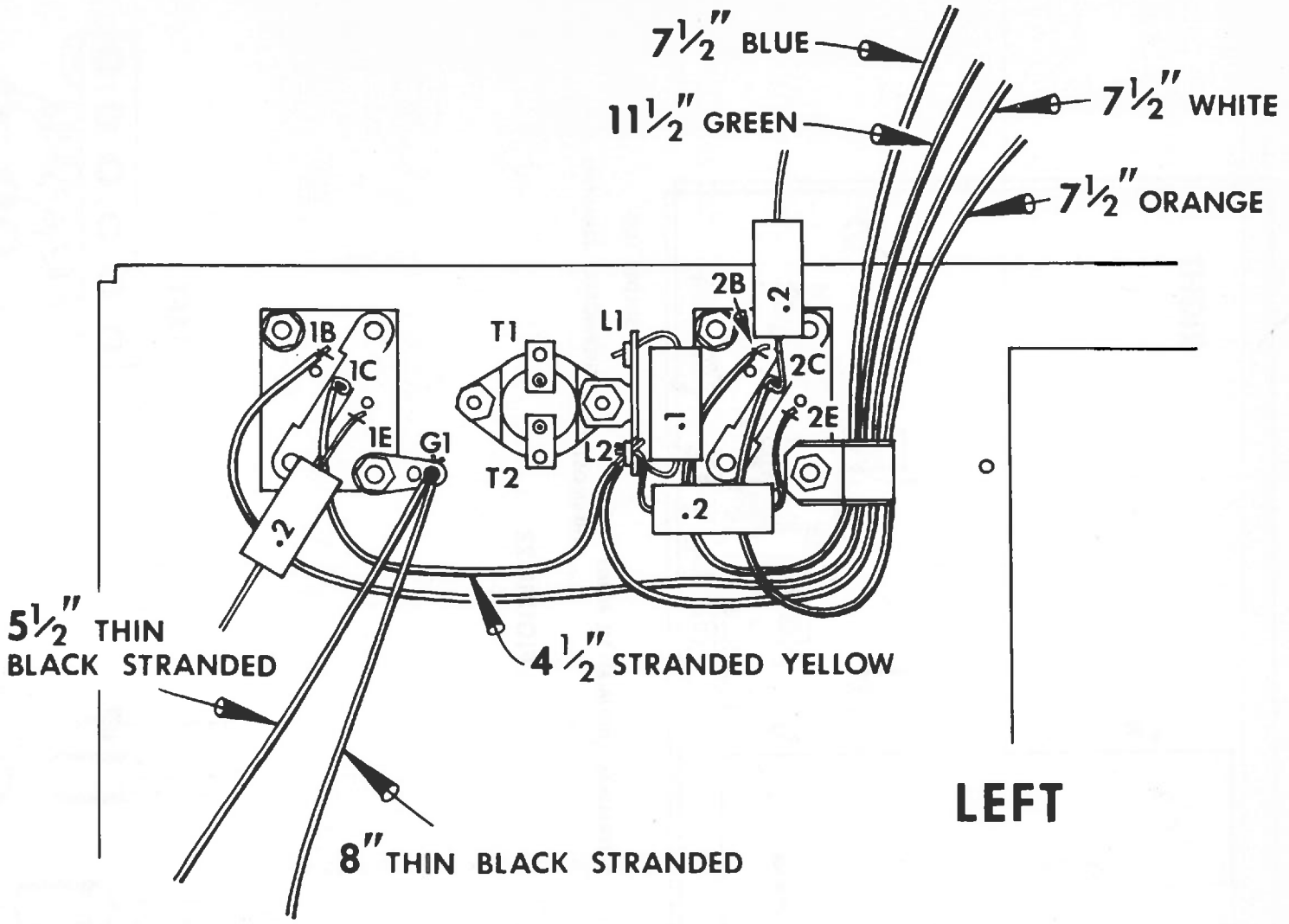



FIGURE 25

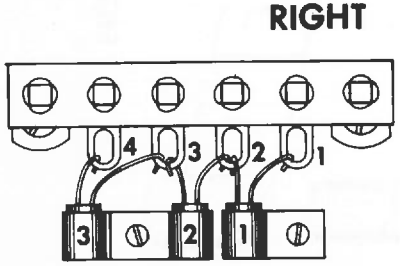



FIGURE 26

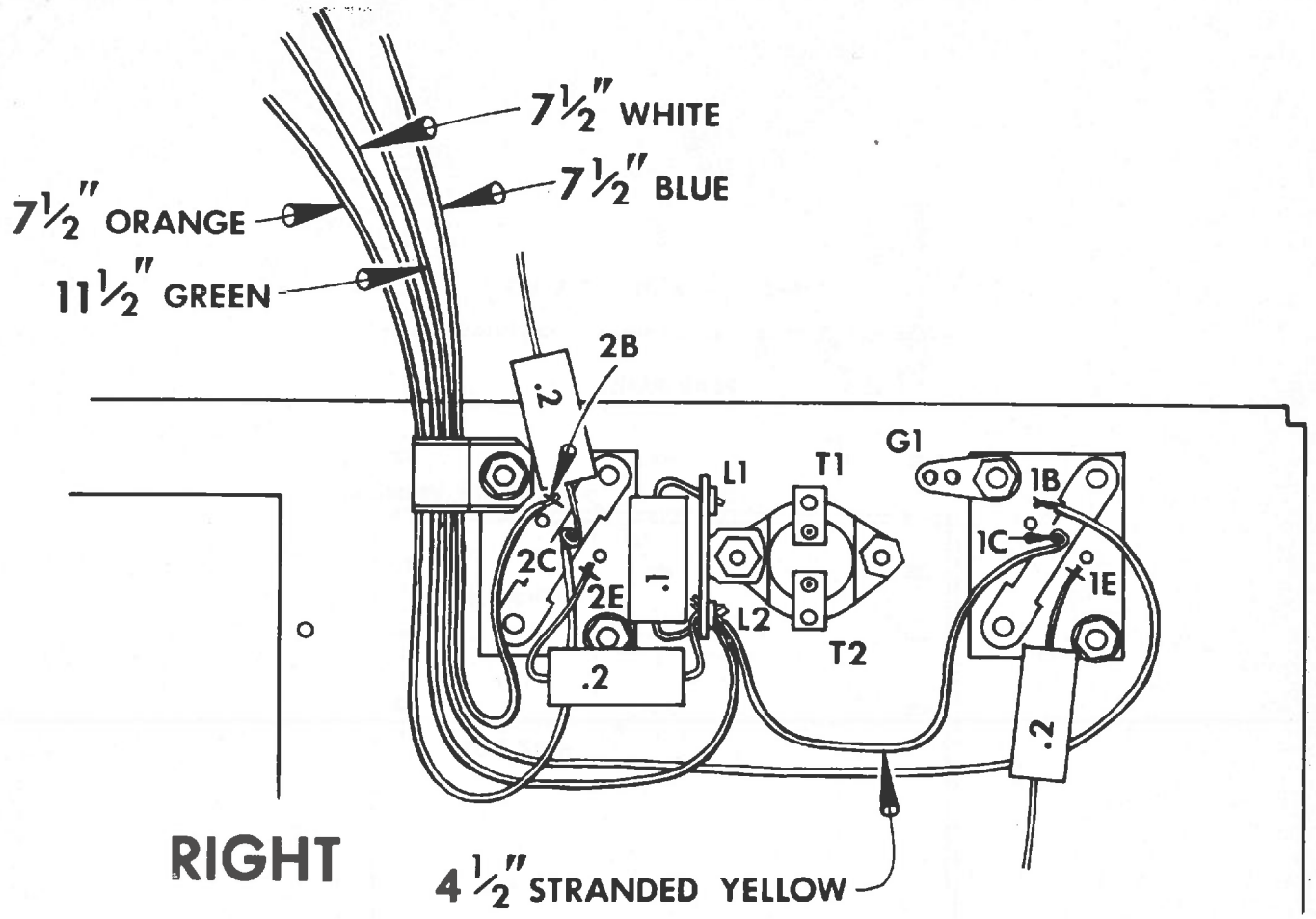



FIGURE 27

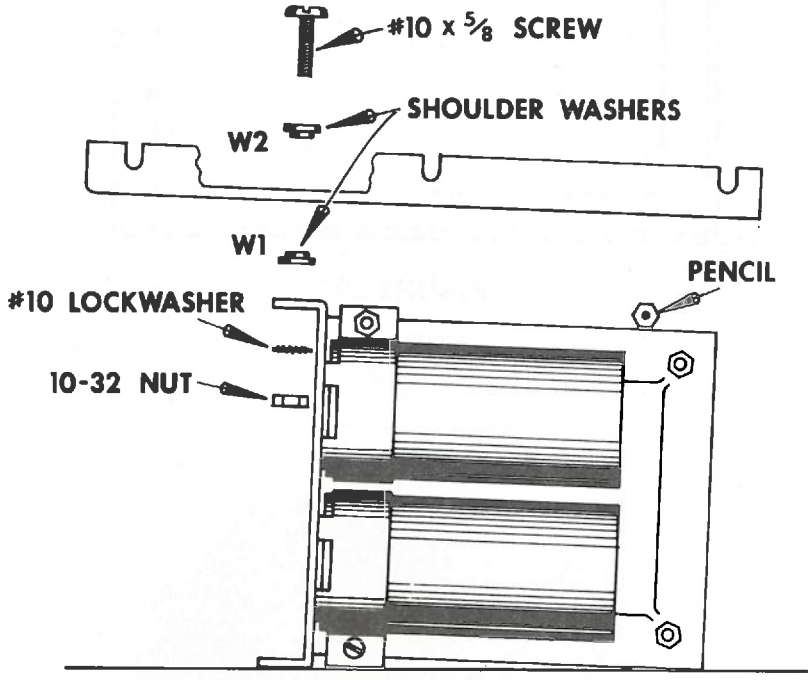



FIGURE 28

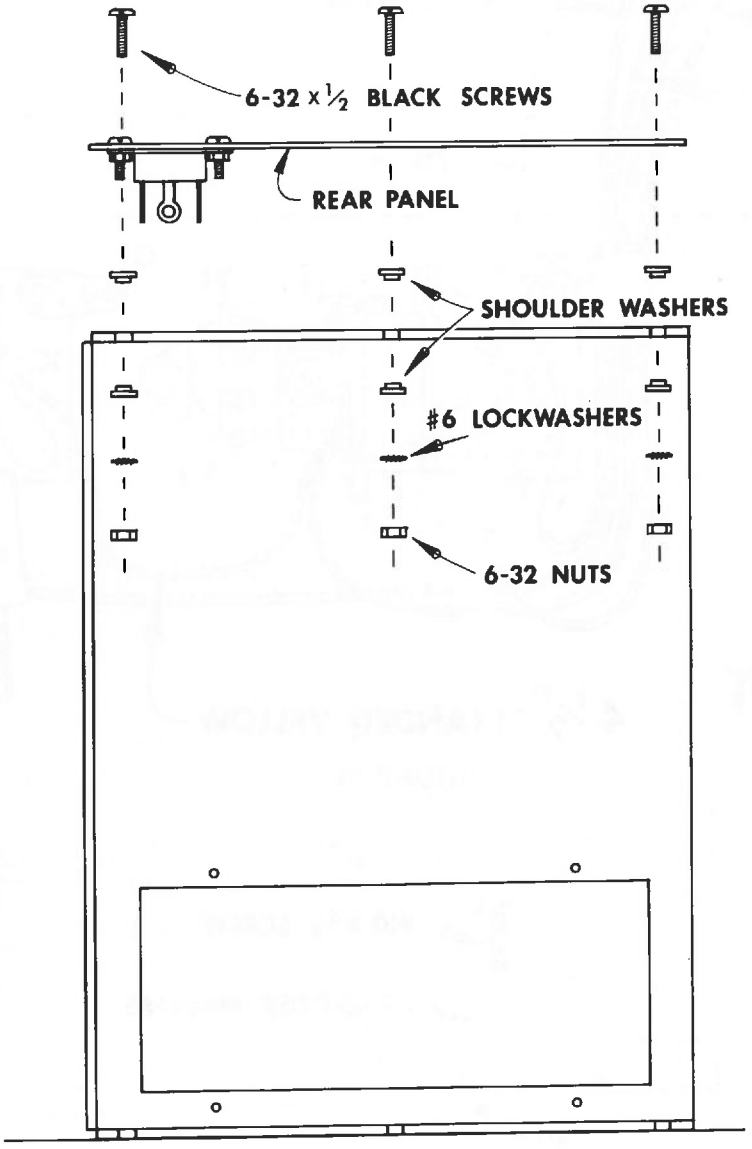

6-32 x ½ BLACK SCREWS
REAR PANEL
SHOULDER WASHERS
#6 LOCKWASHERS
6-32 NUTS

FIGURE 29

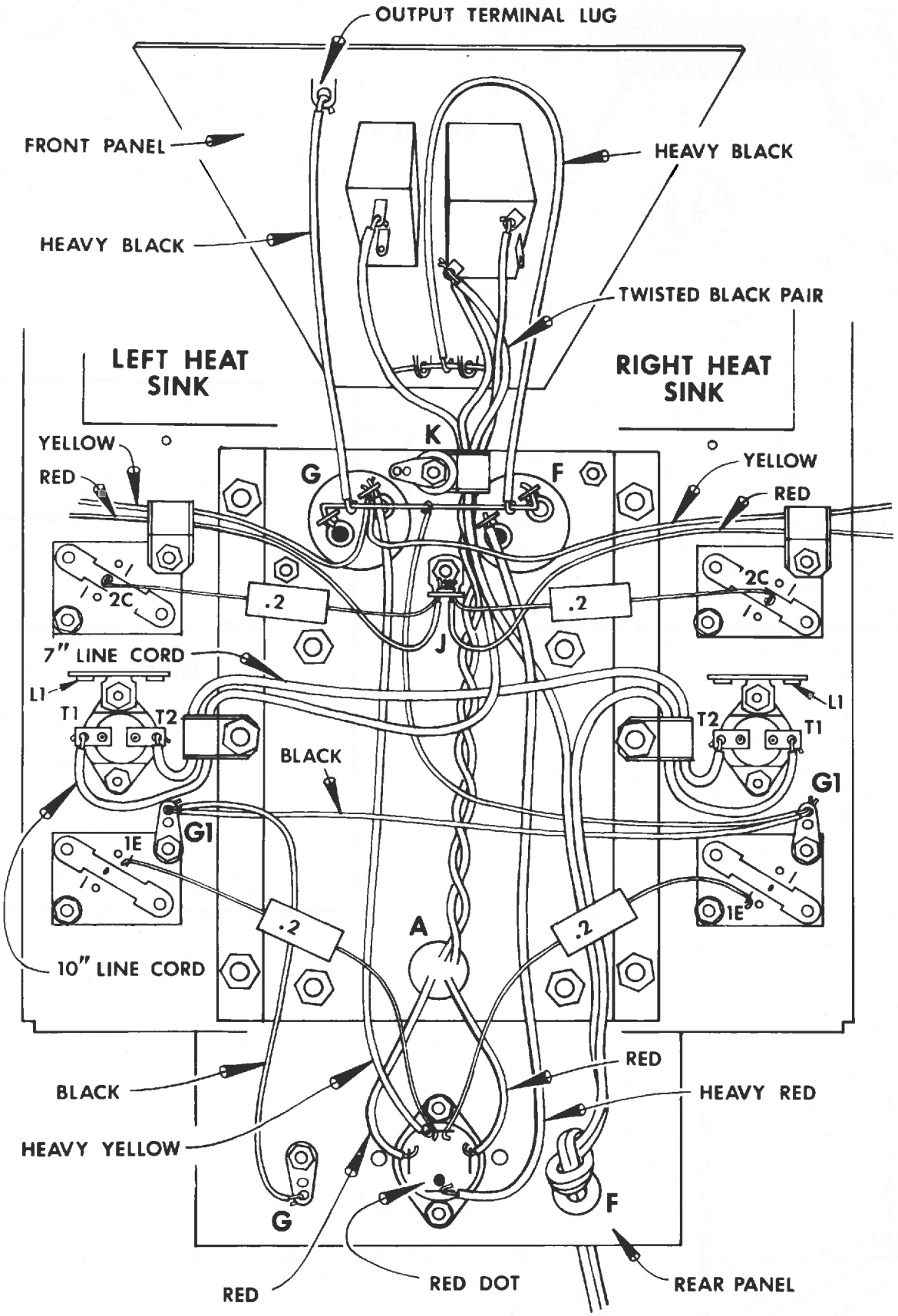

OUTPUT TERMINAL LUG
FRONT PANEL
HEAVY BLACK
HEAVY BLACK
TWISTED BLACK PAIR
LEFT HEAT SINK
RIGHT HEAT SINK
YELLOW
RED
K
G
F
YELLOW
RED
2C
.2
.2
2C
J
7" LINE CORD
L1
T1
T2
T2
T1
L1
BLACK
G1
G1
1E
1E
.2
A
.2
10" LINE CORD
BLACK
HEAVY YELLOW
RED
HEAVY RED
G
F
RED
RED DOT
REAR PANEL

FIGURE 30

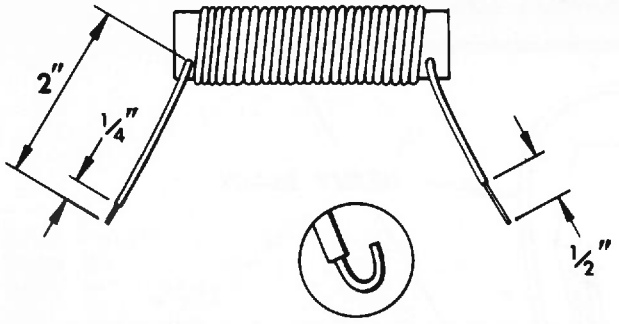



FIGURE 31

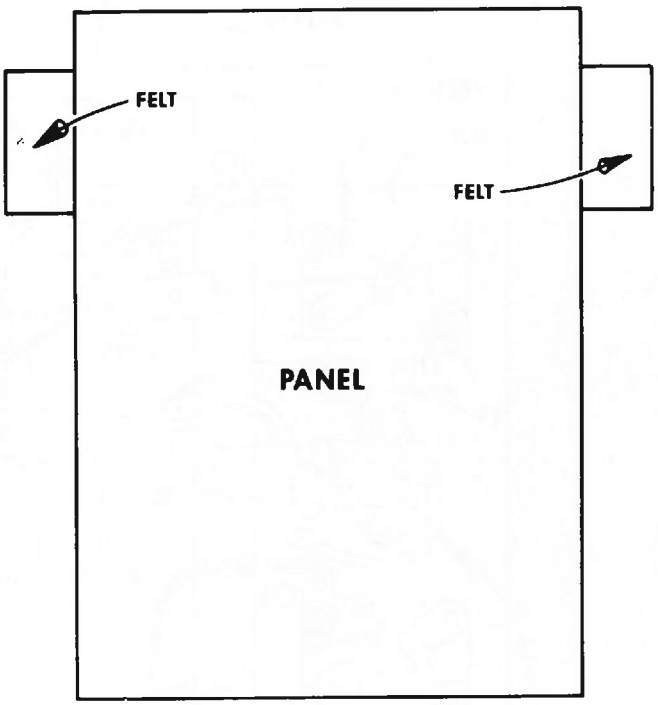



FIGURE 32

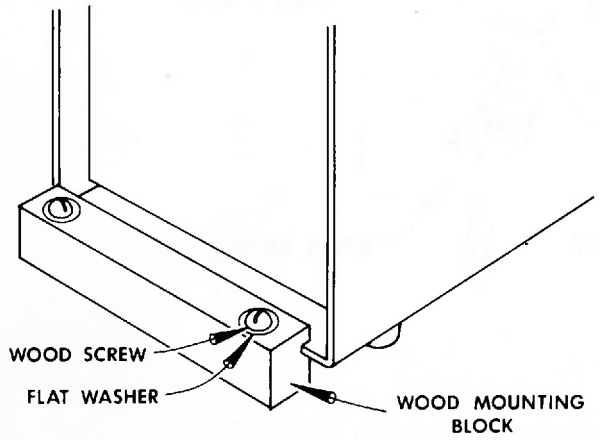
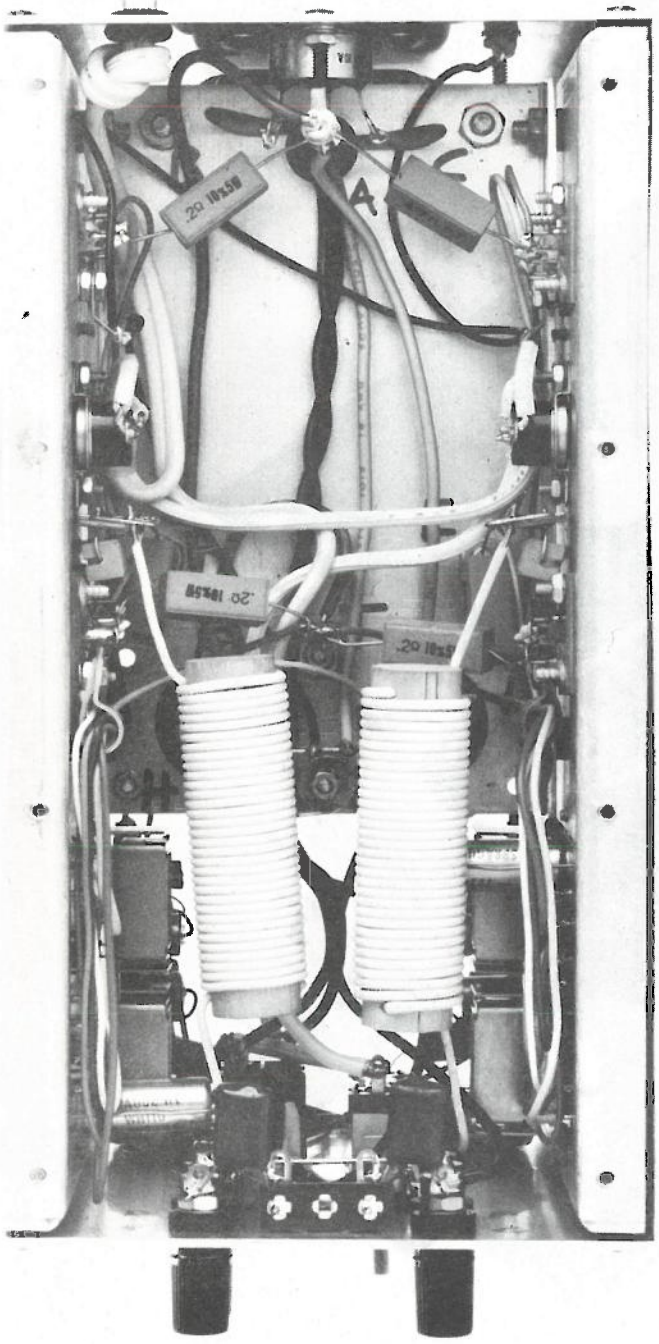
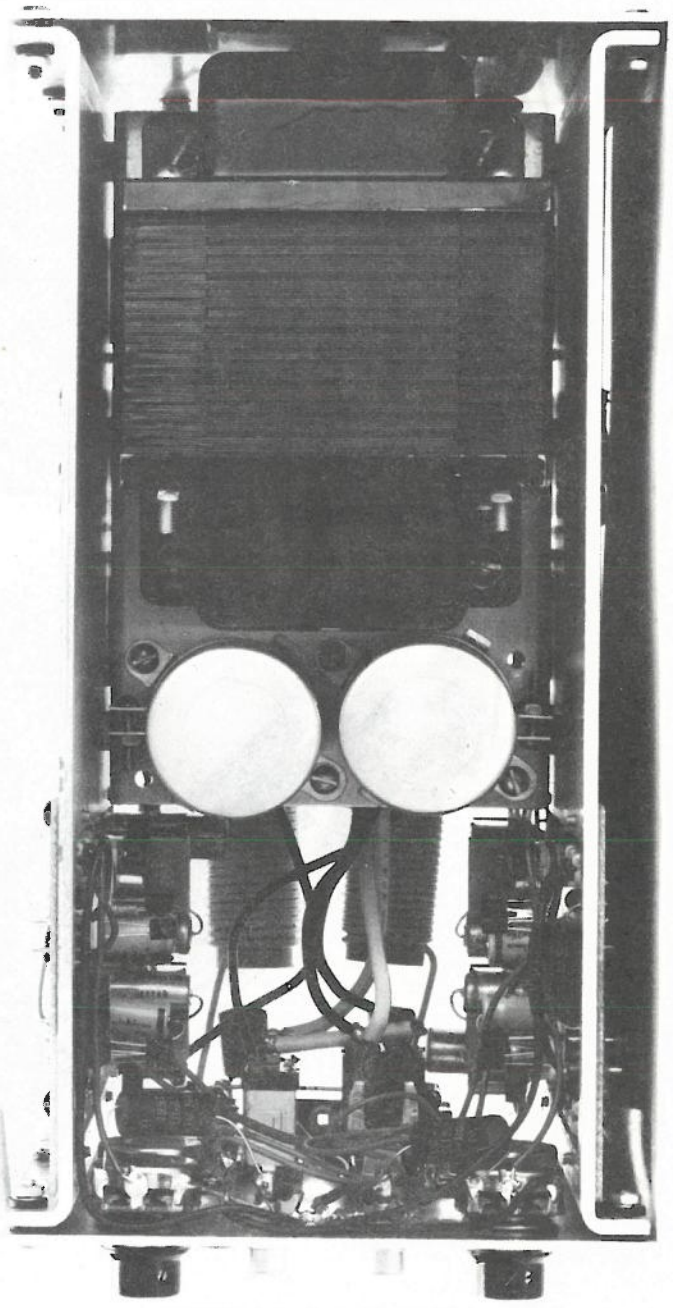



FIGURE 33

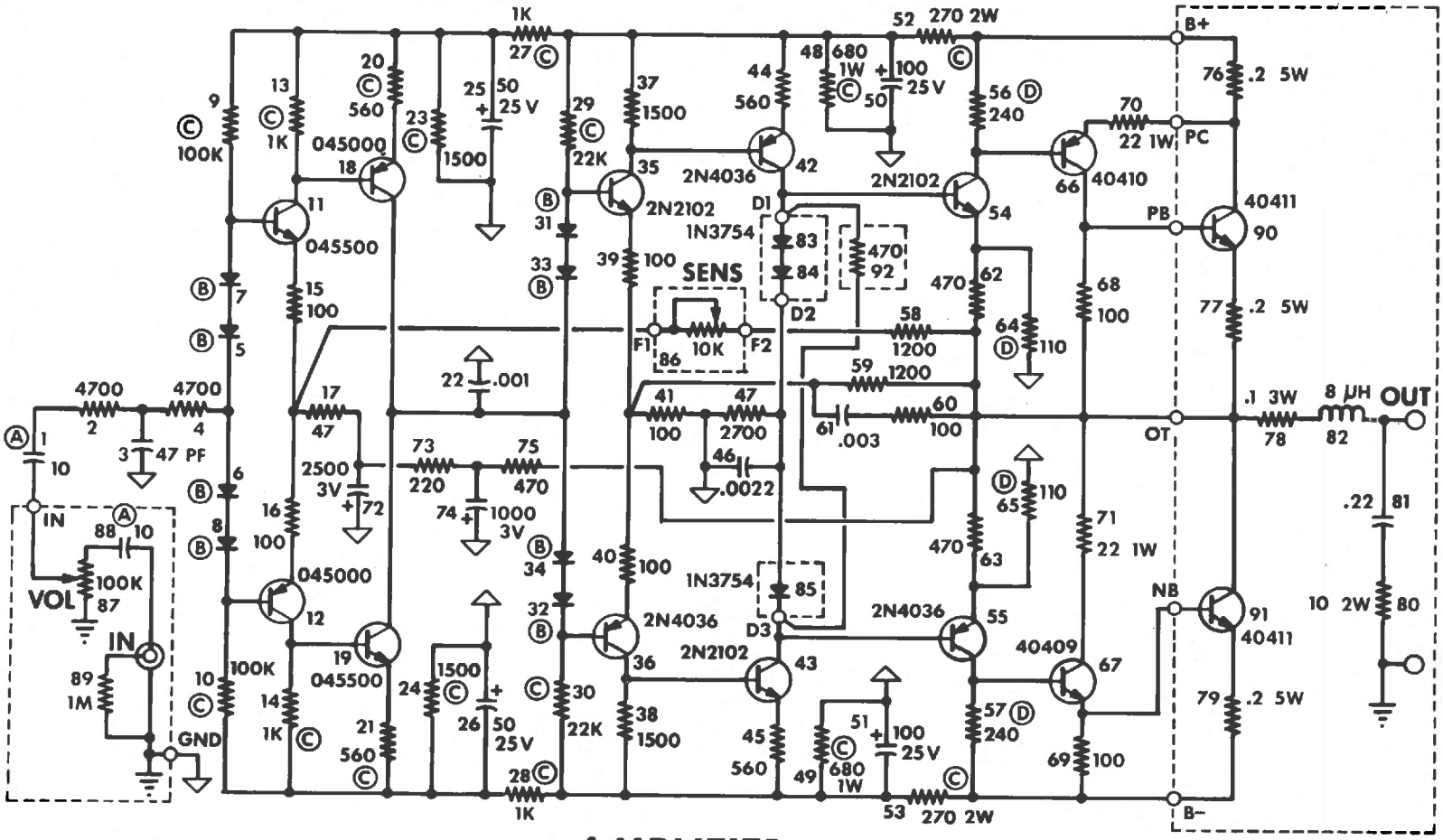


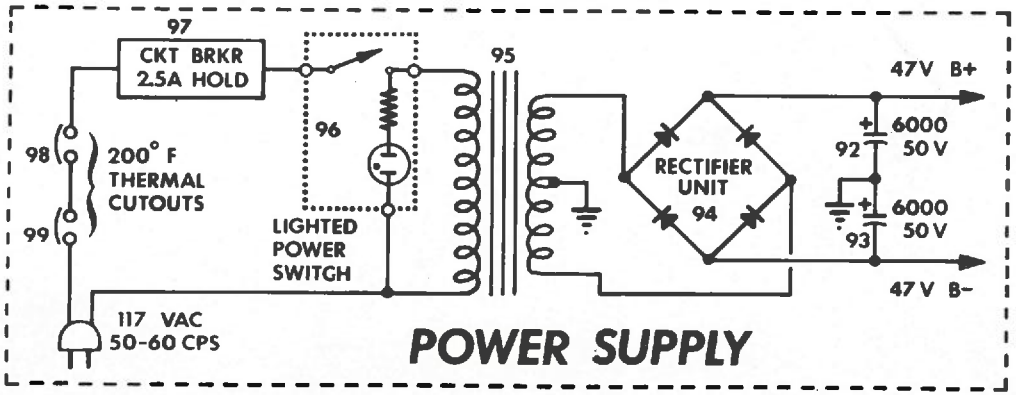
BOTTOM VIEW



TOP VIEW

FINISHED AMPLIFIER WITHOUT CASE




## SCHOBER TR-3 POWER AMPLIFIER

All resistors ½-watt, 5 or 10% unless noted.
Capacitors in microfarads unless noted.
▽ Printed circuit board common.
⏚ Chassis ground.
Quiescent B− and B+ voltages shown. Values at full rated output are 42 for TR-3D, 44 for TR-3M.
Ⓐ Nonpolarized electrolytic capacitor.
Ⓑ Selected diode.
Ⓒ Resistor matched to its counterpart in other side of push-pull circuit.
Ⓓ Resistor selected for ±1% tolerance.